

AD-A147 158

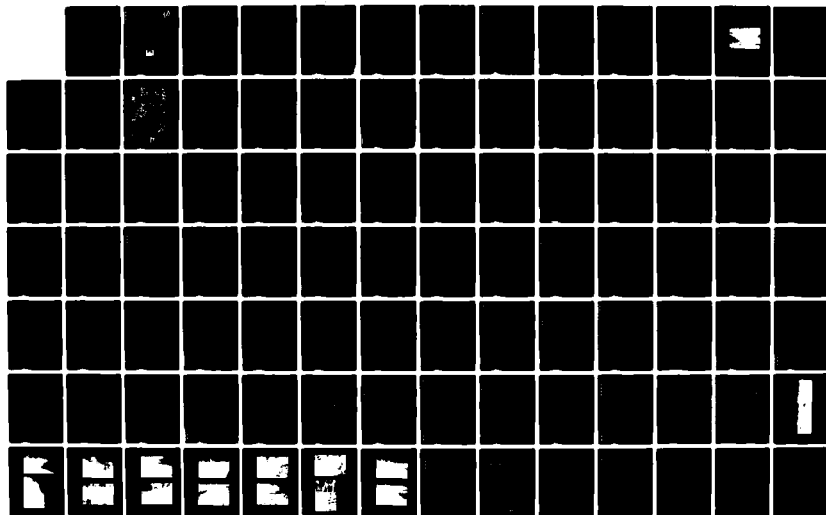
NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS  
FERNWOOD LAKE DAM (MA...) CORPS OF ENGINEERS WALTHAM  
MA NEW ENGLAND DIV APR 79

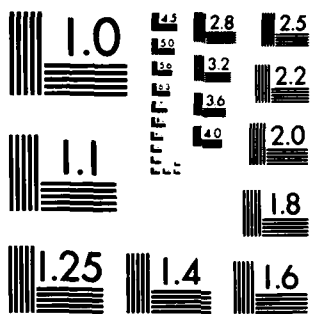
1/2

UNCLASSIFIED

F/G 13/2

NL

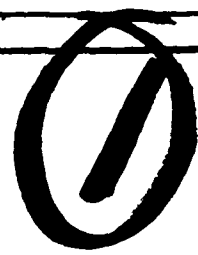




MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A147 158

MASSACHUSETTS COASTAL BASIN  
GLOUCESTER, MASSACHUSETTS



FERNWOOD LAKE DAM  
MA 00184

PHASE I INSPECTION REPORT  
NATIONAL DAM INSPECTION PROGRAM

DTIC FILE COPY



DTIC  
ELECT  
NOV. 6 1984  
S D

DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS. 02154

APRIL, 1979

DISTRIBUTION STATEMENT A

Approved for public release;  
Distribution Unlimited

84 10 29 030



DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
424 TRAPELO ROAD  
WALTHAM, MASSACHUSETTS 02154

REPLY TO  
ATTENTION OF  
NEDED

MAY 30 1980

Honorable Edward J. King  
Governor of the Commonwealth of  
Massachusetts  
State House  
Boston, Massachusetts 02133

Dear Governor King:


Inclosed is a copy of the Fernwood Lake Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. In addition, a copy of the report has also been furnished the owner, the city of Gloucester.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for your cooperation in carrying out this program.

Sincerely,

  
MAX B. SCHEIDER  
Colonel, Corps of Engineers  
Division Engineer

Incl  
As stated

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A/1	

MASSACHUSETTS COASTAL BASIN  
GLOUCESTER, MASSACHUSETTS

FERNWOOD LAKE DAM

MA 00184

PHASE I INSPECTION REPORT  
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS. 02154

APRIL 1979

PHASE I INVESTIGATION REPORT  
NATIONAL DAM INSPECTION PROGRAM

Identification No.:	MA 00184
Name of Dam:	Fernwood Lake (North)
Town:	Gloucester
County:	Essex
State:	Massachusetts
Stream:	Tributary to Annisquam River
Date of Site Visit:	6 December 1978

BRIEF ASSESSMENT

Fernwood Lake Dam consists of an earth embankment approximately 450 ft. in length and a 19-ft. long flash-board controlled spillway at the right abutment. Originally built in 1877, the dam was modified in 1929 by the addition of the spillway and a vertical stone wall on the upstream side of the embankment. To further protect the dam against overtopping, the embankment was raised at that time by 2 ft. to its current maximum height of 19 ft. There is no low-level outlet at the dam site. There are two other dams and a dike at other locations on the lake, all of which have crests up to 2.1 ft. lower than Fernwood Lake (North) Dam.

Due to the extent of downstream development that would be affected in the event the dam were to fail, Fernwood Lake Dam is confirmed as having a "high" hazard potential in accordance with Corps of Engineers guidelines. The other water control structures on the lake were confirmed as having a "low" hazard potential by the Corps of Engineers and are thus excluded from the scope of this investigation.

The dam is in fair condition, based on a visual examination of the structure. Although several deficiencies were noted, there was no evidence of excessive settlement or lateral movement or other signs of structural failure, or other conditions which would warrant urgent remedial action.

Based on the "small" size and "high" hazard potential classifications in accordance with Corps of Engineers Guidelines, the test flood for this dam is one-half the Probable Maximum Flood (1/2 PMF). With the water level at the top of dam, the spillway capacity with flashboards is about 370 cfs. Hydraulic analyses indicate that the test flood outflow of 370 cfs (inflow 475 cfs or 913 csm) would overtop East Dam by 0.5 ft. and South Dike by 0.3 ft. at other locations on the lake, although a free-board of 1.6 ft. would remain at Fernwood Lake (North)

Dam. With the water level at the top of East Dam (lowest dam on lake), the spillway capacity with flashboards is about 80 cfs or 22 percent of the peak test flood outflow.

The City of Gloucester, owner of the dam, should engage a registered professional engineer to 1) investigate methods to increase discharge, raise other dams on the lake or otherwise prevent the overtopping of any other dams on Fernwood Lake by the test flood, 2) assess seepage occurring at the dam and 3) assess the potential for a failure of the dam under earthquake loading conditions, as outlined in Section 7.2. Any necessary modifications resulting from this assessment, and remedial measures, including clearing of trees, brush and debris on the embankment slopes and in the downstream channel, removing stumps and roots and placing fill to restore the embankment cross-section, repairing eroded and bare areas on the embankment, and repairing the upstream wall where it has deteriorated, as outlined in Section 7.3, should be implemented by the Owner within one year after receipt of this report.

HALEY & ALDRICH, INC.  
by:



Harl Aldrich  
President



## PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the office of Chief of Engineers, Washington, DC 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I Investigations are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the test flood is based on the estimated "probable maximum flood" for the region (greatest reasonably possible storm run-off), or a fraction thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential. Consideration of downstream flooding other than in the event of a dam failure is beyond the scope of this investigation.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

## TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
LETTER OF TRANSMITTAL	
BRIEF ASSESSMENT	
REVIEW BOARD PAGE	
PREFACE	i
TABLE OF CONTENTS	iii
OVERVIEW PHOTO	vi
LOCATION MAP	vii
 1. PROJECT INFORMATION	
1.1 General	1
a. Authority	1
b. Purpose of Inspection	1
1.2 Description of Project	2
a. Location	2
b. Description of Dam and Appurtenances	2
c. Size Classification	3
d. Hazard Classification	3
e. Ownership	4
f. Operator	4
g. Purpose of Dam	4
h. Design and Construction History	4
i. Normal Operational Procedures	5
1.3 Pertinent Data	5
 2. ENGINEERING DATA	
2.1 Design Data	9
2.2 Construction Data	9
2.3 Operation Data	9
2.4 Evaluation of Data	9

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
3. VISUAL EXAMINATION	
3.1 Findings	10
a. General	10
b. Dam	10
c. Appurtenant Structures	11
d. Reservoir Area	11
e. Downstream Channel	12
3.2 Evaluation	12
4. OPERATIONAL PROCEDURES	
4.1 Procedures	14
4.2 Maintenance of Dam	14
4.3 Maintenance of Operating Facilities	14
4.4 Description of any Warning System in Effect	14
4.5 Evaluation	14
5. HYDRAULIC/HYDROLOGIC	
5.1 Evaluation of Features	15
a. General	15
b. Design Data	15
c. Experience Data	15
d. Visual Observations	15
e. Test Flood Analysis	16
f. Dam Failure Analysis	17
6. STRUCTURAL STABILITY	
6.1 Evaluation of Structural Stability	18
a. Visual Observations	18
b. Design and Construction Data	18
c. Operating Records	18
d. Post-Construction Changes	18
e. Seismic Stability	19

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
7. ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES	
7.1 Dam Assessment	20
a. Condition	20
b. Adequacy of Information	20
c. Urgency	20
d. Need for Additional Investigation	20
7.2 Recommendations	20
7.3 Remedial Measures	21
a. Operation and Maintenance Procedures	21
7.4 Alternatives	22
APPENDIX A - INSPECTION CHECKLIST	A-1
APPENDIX B - ENGINEERING DATA	B-1
APPENDIX C - PHOTOGRAPHS	C-1
APPENDIX D - HYDROLOGIC AND HYDRAULIC COMPUTATIONS	D-1
APPENDIX E - INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS	E-1



1. Overview of Fernwood Lake Dam from right abutment

APPENDIX A - INSPECTION CHECK LIST

	<u>Page</u>
<u>VISUAL INSPECTION PARTY ORGANIZATION</u>	A-1
<u>VISUAL INSPECTION CHECK LIST</u>	
Dam Embankment	A-2
Outlet Works - Spillway Weir, Approach and Discharge Channel	A-3
Outlet Works - West Dam	A-4

LIST OF AVAILABLE DATA  
FERNWOOD LAKE DAM

<u>Document</u>	<u>Contents</u>	<u>Location</u>
Essex County inspection reports, Gloucester Dam D.9	Report dated 7 July 1971 and summary of 26 inspections from 1917 through 1969	Essex County Engineers Office, 32 Federal Street, Salem, MA 01970 and page B-3
Report and Record of Inspection in Connection with Raising Dam and Building New Spillway, 1929, Essex County Engineer	Daily inspection reports and a summary letter including design and construction details concerning the new spillway, raising the embankment and placing an upstream masonry wall	Essex County Engineers Office and page B-8
State inspection reports, Gloucester Dam No. 5-5-107-9	One report dated 7 July 1971 and location map	Mass. Dept. of Environmental Quality Engineering, Division of Waterways, 100 Nashua Street, Boston, MA 02114 and page B-21
County of Essex Record No. 2430, Cape Pond Ice Co. Proposed Dam, 5 September 1929, John H. Griffin, Engineer	Plan and sections of proposed spillway for the 1929 modifications to dam	Essex County Engineers Office and page B-23
Operation records	Reservoir levels	Gloucester Public Works Dept., Poplar Street, Gloucester, MA 01930

LIST OF SUPPLEMENTAL DATA  
OTHER DAMS ON FERNWOOD LAKE

<u>Document</u>	<u>Contents</u>	<u>Location</u>
Plan of Land in West Gloucester Purchased from the Cape Pond Ice Company by the City of Gloucester, 4 February 1952	Plan of Fernwood Lake (with the locations of Fernwood Lake Dam and other dams on Fernwood Lake added to the drawing)	Gloucester Public Works Department and page B-24
Essex County inspection reports, Gloucester Dam D.7 (West Dam)	Report dated 24 April 1912 and summary of 25 inspections from 1917 through 1969 of dam along the southwest shoreline and also the dike across the south end of the lake	Essex County Engineers Office and page B-25
State inspection reports, Gloucester Dam No. 5-5-107-9A (West Dam)	One report dated 7 July 1971 of dam on southwest shoreline, including a location map	Mass. Department of Environmental Engineering and page B-31
Essex County inspection reports, Gloucester Dam D.8 (East Dam)	Report dated 24 April 1912 and summary of 22 inspections from 1917 through 1966 of dam at outlet to Upper Banjo Pond	Essex County Engineers Office and page B-33



PHASE I INVESTIGATION REPORT  
NATIONAL DAM INSPECTION PROGRAM  
FERNWOOD LAKE DAM  
MA 00184

SECTION 1 - PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region.

Haley & Aldrich, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed were issued to Haley & Aldrich, Inc. under a letter dated 28 November 1978 from Colonel Max B. Scheider, Corps of Engineers. Contract No. DACW33-79-C-0018 has been assigned by the Corps of Engineers for this work. Camp, Dresser & McKee, Inc. was retained as consultant to Haley & Aldrich, Inc. on the structural, mechanical/electrical and hydraulic/hydrologic aspects of the Investigation.

b. Purpose of Inspection. The primary purposes of the National Dam Inspection Program are to:

1. Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

2. Encourage and prepare the states to initiate quickly effective dam safety programs for non-Federal dams.

3. To update, verify and complete the National Inventory of Dams.

## 1.2 Description of Project

a. Location. The dam is located at the northern end of Fernwood Lake in Gloucester, MA, as shown on the Location Map, page vii. The coordinates of the dam site are  $N42^{\circ}36.8'$ ,  $W70^{\circ}42.0'$ . Spillway discharge from the dam is conveyed by an open channel northward for approximately 2,200 ft. to the tidal basin of the Annisquam River.

In addition to Fernwood Lake (North) Dam, there are three other water retaining structures on the lake. They are referred to in this report as the East Dam, West Dam and South Dike, based on their relative locations as shown on the plan of land included as page B-24.

b. Description of Dam and Appurtenances. Fernwood Lake Dam consists of a curved earth embankment approximately 450 ft. in length with a flashboard-controlled spillway weir 19 ft. in length at the right abutment. A gate valve control for an abandoned reservoir drain pipe is located in the spillway approach channel. The general configuration of the dam and appurtenant structures is shown on the Site Plan Sketch, page C-1.

The earth embankment is approximately 12 ft. wide at the crest. A vertical stone masonry wall extends along the entire length of embankment on the upstream side. Stone riprap, earth and rubble have been placed upstream of the stone wall, generally up to about 4 ft. below the top, at a slope of approximately 1.7 horizontal (H) to 1 vertical (V). The upstream stone and rubble fill extends up to the level of the capstone along the right 150 ft. of embankment. For about 300 ft. from the left abutment, the embankment has a maximum height of approximately 19 ft. and a downstream slope estimated to be slightly steeper than 2H to 1V. The right 150 ft. of the embankment is part of a private yard and is no higher than 4 ft. above adjacent ground. The top of the dam is lowest towards the left abutment and is estimated to be about El. 95.5 Mean Sea Level Datum (MSL) in that area.

The reinforced concrete spillway structure at the right end of the embankment has a 19 ft. long concrete weir between 3.7 ft. high by 20 ft. long spillway walls. The weir has a grouted stone masonry apron extending downstream about 16 ft. from the weir. The top of the weir is assumed to be at El. 91.0, and the top of the spillway walls would then be at El. 94.7, about 1 ft. lower than most of the embankment. Wooden flashboards

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MA 00184	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Fernwood Lake Dam  NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE April 1979
		13. NUMBER OF PAGES 80
		15. SECURITY CLASS. (of this report)  UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report)  APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) DAMS, INSPECTION, DAM SAFETY, Mass. Coastal Basin Gloucester, Mass.,		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Fernwood Lake Dam, consists of an earth embankment approximately 450 feet in length and a 19 ft. long flashboard controlled spillway at the right abutment. The dam is in fair condition, based on a visual examination of the structure. Based on the "small" size and "high" hazard potential, the test flood for this dam is 1/2 the PMF.		

1.3 ft. in height are rigidly secured to two 14 in. square by 15 in. high concrete piers spaced equally along the length of the weir. A private yard abuts the right spillway wall.

A visual examination and evaluation of the conditions at the three other water retaining structures on Fernwood Lake were excluded from the scope of this investigation because the New England Division of the Corps of Engineers confirmed that these structures have a "low" hazard potential. Briefly, they consist of (1) a low East Dam on the east shoreline at the outlet to Upper Banjo Pond, (2) a South Dike across the southern tip of the lake, creating a separate pond and (3) a West Dam along the west shoreline similar in construction to Fernwood Lake (North) Dam, with an outlet for flow to Wallace Pond.

Only the pertinent data summarized below were obtained for these structures to complete the hydraulic/hydrologic aspects of the evaluation of Fernwood Lake Dam:

<u>Identification of Structure, Based on Location</u>	<u>Estimated Length, ft.</u>	<u>Estimated Elevation at top of Embankment, ft. above MSL</u>
East Dam	100	93.4
South Dike	325	93.6
West Dam	400	95.4

Additional information regarding these structures is contained in prior county and state inspection reports included in Appendix B, in the section entitled "Supplemental Inspection Reports".

c. Size Classification. The storage to the top of Fernwood Lake Dam is estimated to be 380 acre-ft., and the corresponding maximum height of the dam is approximately 19 ft. Storage of less than 1,000 acre-ft. and a height of less than 40 ft. classifies the dam in the "small" size category, according to the guidelines established by the Corps of Engineers.

d. Hazard Classification. Based on the Phase I investigation and the dam failure analysis (Section 5.1f), Fernwood Lake Dam was found to have a high hazard potential according to the Corps of Engineers Guidelines. Depending on the location of the failure section along the embankment, the house next to the dam to the left of the spillway, the paved access road to the dam site, four single family homes and a garage-repair shop on the northern side of the Essex Avenue, and seven single family homes beyond the B & M

railroad to the north could be subject to flooding. The potential for loss of life would be high and damages to the properties would be excessive.

e. Ownership. The name, address and phone number of the current owner are:

City of Gloucester  
Public Works Department  
Poplar Street  
Gloucester, MA 01930  
Phone: (617) 283-5940

Mr. Robert Martinack is the acting director of the Public Works Department.

The City of Gloucester purchased Fernwood Lake and some adjacent shoreline, including the dam, in 1952. Prior to that, the property was owned by the Cape Pond Ice Company which dates back to 1887, the year the dam was originally constructed.

f. Operator. Mr. Wilford Burke, Chief Operator, is responsible for operation, maintenance and safety of the dam, and has been associated with the Public Works Department for 31 years. His phone number is (617) 283-8422.

g. Purpose of Dam. The lake is used only as a water supply for the City of Gloucester. The original purpose of the dam was to impound water for cutting ice.

h. Design and Construction History. No details of the original construction were disclosed. The earliest available county inspection report, dated 23 April 1912 and included as page B-3, contains a statement that T.W. Romans of the Cape Pond Ice Co. owned this dam in 1877 and probably built it himself. A sketch of a typical section of the dam indicates the embankment was originally about 16 ft. in height. The report goes on to say that there was no overflow spillway at that time, but an old 8-in. diameter drawoff pipe was present. The 1925 county report page B-4, contains the statement "There was formerly a wasteway at the north dam but this has been filled in." The 1928 county report, also page B-4, contains the statement "The old eight inch drawoff at the dam has been clogged up and is not in use now".

The dam was repaired and modified in 1929 because

the Essex County Engineer felt that the dam should be raised to guard against damage by waves and that a large enough spillway to automatically take care of overflow should be added. Consequently, a new spillway was constructed at an old watercourse near the right abutment where a spillway formerly existed, according to the drawing included as page B-23. The earth embankment was raised approximately 2 ft., and a stone masonry wall was laid on the upstream side for the entire length of the embankment. Further details of the design considerations and construction sequence of the 1929 work are given in several county inspection reports included in Appendix B.

i. Normal Operational Procedures. Operational procedures at the Fernwood Lake (North) dam consist of measuring and recording water surface elevations at the spillway on a weekly basis. The flashboards are simply left in place at all times. Additional routine maintenance is performed as required.

At the toe of the West Dam, a gated 18-in. diameter draw-off pipe, which is normally closed, serves to supplement the water supply of Wallace Pond. It is understood that the operator, as required, will open the gate valve for this draw-off pipe to allow water from Fernwood Lake to feed into a brook which, in turn, feeds into Wallace Pond.

### 1.3 Pertinent Data

In lieu of better information, all elevations reported herein are approximate and based on the assumption that the top of the concrete spillway weir is at El. 91.0 MSL (the level of Fernwood Lake shown on the USGS Gloucester Quadrangle Map).

a. Drainage Area. The drainage area of the Fernwood Lake Dam is approximately 335 acres (0.52 sq. mi.) and is located south of Essex Avenue in western Gloucester, about 2,000 ft. inland from the Atlantic. Elevations in the watershed vary from a low of about El. 90 to a high of about El. 200. The drainage area consists of approximately 70 percent well preserved woodlands, 10 percent water surface and 20 percent swamp.

#### b. Discharge at Dam Site.

1. Outlet works..... 8-in. pipe at

North Dam; in-operable. 18-in. pipe at West Dam; used occasionally to supplement Wallace Pond. 8-in. pipe at East Dam; blocked off

2. Maximum known flood at dam site..... Recorded in December 1968; flow unknown, pool level El.93.3
3. Spillway capacity at top of Fernwood Lake (North) Dam  
 (with flashboards)..... 370 cfs at El. 95.5\*  
 (without flashboards)..... 640 cfs at El. 95.5\*
- 3a. Spillway capacity at top of East (lowest) Dam  
 (with flashboards)..... 80 cfs at El. 93.4  
 (without flashboards)..... 130 cfs at El. 93.4
4. Spillway capacity at test flood pool elevation  
 (with flashboards)..... 150 cfs at El. 93.9\*\*  
 (without flashboards)..... 160 cfs at El. 93.8\*\*
5. Gated spillway capacity at normal pool elevation..... Not applicable
6. Gated spillway capacity at test flood pool elevation..... Not applicable
7. Total spillway capacity at test flood pool elevation  
 (with flashboards)..... 150 cfs at El. 93.9\*\*  
 (without flashboards)..... 160 cfs at El. 93.8\*\*
8. Total project discharge at test flood pool elevation  
 (with flashboards)..... 370 cfs at El. 93.9\*\*\*  
 (without flashboards)..... 300 cfs at El. 93.8\*\*\*

c. Elevation (ft. above MSL)

1. Lowest ground at downstream toe of dam..... Approx. 76.5
2. Maximum tailwater..... Unknown
3. Upstream portal invert diversion tunnel..... Not applicable

\*The East Dam, South Dike and West Dam would be overtopped

\*\*The East Dam and South Dike would be overtopped

\*\*\*Including overflows at the East Dam and South Dike

4. Normal Pool..... 91.0
5. Full flood control pool..... Not applicable
6. Spillway crest  
(without flashboards)..... 91.0  
(with flashboards)..... 92.3
7. Design surcharge-original  
design..... Unknown
8. Top of dam..... 95.5 minimum
9. Test flood design surcharge... 93.8

d. Reservoir

1. Length of maximum pool..... 0.4 mi. (Est.)
2. Length of normal pool..... 0.4 mi. (Est.)
3. Length of flood control pool.. Not applicable

e. Storage (acre-ft.)

1. Normal pool..... 225
2. Flood control pool..... Not applicable
3. Spillway crest..... 225
4. Top of dam..... 380
5. Test flood pool..... 320

f. Reservoir Surface (acres)

1. Normal pool..... 28
2. Flood control pool..... Not applicable
3. Spillway crest..... 28
4. Test flood pool..... 36
5. Top of dam..... 41

g. Dam Embankment

1. Type..... Earth, with dry-laid stone masonry wall on upstream side
2. Length..... Approx. 450 ft.
3. Height..... Approx. 19 ft. max.
4. Top width..... Approx. 12 ft.
5. Side slopes..... Vertical wall upstream with fill placed 1.7 H to 1V; downstream slope slightly steeper than 2H to 1V

- 6. Zoning..... Unknown
- 7. Impervious core..... Unknown
- 8. Cutoff..... Unknown
- 9. Grout curtain..... Unlikely
- 10. Other..... Embankment raised  
approximately 2 ft.  
in 1929

h. Diversion and Regulating Tunnel. Not applicable

i. Spillway

- 1. Type..... Concrete overflow  
weir 18 in. wide  
and about 0.5 ft.  
above the channel
- 2. Length of weir..... 19 ft.
- 3. Crest elevation..... 91.0
- 4. Gates..... None (flashboards  
are a maximum of  
1.3 ft. in height)
- 5. U/S channel..... Cut into natural  
ground at a slope  
of 1/2 in. per foot
- 6. D/S channel..... Paved with grouted  
stone masonry for  
a length of 16 ft.;  
width is about 20  
ft.

j. Regulating Outlets. It is reported that there is an abandoned pipe left in place under the spillway at Fernwood Lake Dam. Although a valve box is visible upstream of the weir, the size of the pipe and the locations of the inlet and outlet ends are unknown. It would appear that the pipe has not been used for some time.

There is an 18-in. diameter draw-off pipe through the West Dam which exits at about El. 84.5 into a brook that flows to Wallace Pond. The inlet of the draw-off pipe was submerged on the day of the site visit. There was no available data disclosed for accurately determining the inlet invert, but it can be reasonably estimated to be at El. 85. The operator periodically opens the gate, which is normally closed, allowing water from Fernwood Lake to supplement the supply at Wallace Pond.

There is also an 8-in. diameter pipe through the small East Dam near Upper Banjo Pond. This pipe, which was at about water surface elevation during the site visit, is broken and blocked up. However, no gate control mechanism of any kind was observed.

## SECTION 2 - ENGINEERING DATA

### 2.1 Design Data

No design data for the original dam were located and none are believed to exist. The reasons for building a spillway and raising the embankment in 1929 were to provide adequate discharge and reduce the likelihood of the dam being overtopped, but no actual design calculations were disclosed.

### 2.2 Construction Data

No data concerning the original construction of the dam were disclosed. However, there are one drawing and several county inspection reports that pertain to the modification of the dam in 1929.

### 2.3 Operation Data

The operation data of the dam and the other three water control structures on the lake consist of conditions reported in prior inspection reports dating back to 1912 and water level elevations measured at the spillway at Fernwood Lake Dam on a weekly basis.

### 2.4 Evaluation of Data

a. Availability. A list of the engineering data available for use in preparing this report is included on page B-1. Selected documents from the list are also included in Appendix B.

b. Adequacy. There was a lack of engineering data available to aid in the evaluation of Fernwood Lake Dam. This Phase I assessment was therefore based primarily on visual examination, preliminary hydraulic and hydrologic computations, consideration of past performance and application of engineering judgement.

c. Validity. The limited engineering data may generally be considered valid.

### SECTION 3 - VISUAL EXAMINATION

#### 3.1 Findings

a. General. The Phase I visual examination of Fernwood Lake Dam was conducted on 6 December 1978. The water level was relatively low, approximately 2.3 ft. below the concrete spillway crest.

In general, the project was found to be in fair condition. Seepage was apparent at the toe of the downstream slope, although growth of trees and brush on the slope precluded close examination. However, there was no evidence of piping, excessive settlement or lateral movement, or other serious defects at the time of the visual examination. Several deficiencies which require correction were noted.

A visual inspection check list is included in Appendix A and selected photographs of the project are given in Appendix C. A "Site Plan Sketch", page C-1, shows the direction of view for each photograph.

b. Dam. The upstream slope and crest of the dam are shown in Photo No. 1. The vertical alignment varies by up to 1 ft; the minimum crest level (called top of dam) occurs towards the left abutment, Photo No. 2. In that same area, a 35 ft. long section of the upstream wall has been repaired, Photo No. 3. The horizontal alignment of the upstream wall is fair to good along the section visible from the left abutment, Photo No. 4. However, a section of the wall further right, Photo No. 1, is crumbling and in need of repair. The upstream slope riprap protection is continuous along the section shown in Photo No. 4, but locally eroded and supporting brush growth towards the right end, Photos No. 1, 5 and 6.

The crest and downstream slope of the right 150 ft. of the embankment are part of a grass-covered and mowed private yard adjacent to a home, Photos No. 5 and 8. Several large pine trees and a birch tree are growing along the downstream toe in the yard. The left 300 ft. long portion of the embankment is not well maintained. The crest of this portion is generally grass covered with some weed growth and minor erosion by foot traffic, Photo No. 4. The embankment is highest along this section and the downstream slope is covered by young trees, brush, brambles, dumped tree and brush cuttings, leaves

and trash. A small erosion gulley was observed at the top of the downstream slope 45 ft. from the left abutment. There are several low areas with water locally ponded for 10 to 15 ft. beyond the toe of the dam, but no active seepage was noted.

Bedrock outcrops at the left abutment of the dam. The earth embankment abuts the left spillway wall at the right end. Another private yard adjacent to a home is located to the right of the spillway.

It was apparent during the visual examination that several locations along the shoreline of Fernwood Lake are lower by at least 1 ft. than the top of the embankment of the Fernwood Lake Dam. As previously stated in Section 1.2b., a visual examination of the other three water retaining structures on Fernwood Lake was beyond the scope of this investigation and report. The East Dam was not photographed, but the West Dam and South Dike are shown in Photos No. 15 and 16, respectively.

c. Appurtenant Structures. Generally, the spillway structure is in good condition. The concrete weir extends between two sidewalls and has a grouted stone masonry apron downstream. Approximately 1.3 ft. of wooden flashboards are rigidly secured to two concrete piers, as shown in Photo No. 10. The condition of the wooden flashboards is good. The grouted stone masonry apron appears to be in good condition, although a large portion of the area is silted over and is supporting a heavy growth of grass. The concrete sidewalls of the spillway are shown in Photos No. 11 and 12. There were some minor shrinkage cracks, stains and erosion observed. The general condition of the spillway walls was good.

A valve box was observed upstream of the spillway near the right wall, Photo No. 12. The inlet and the outlet of a pipe controlled by the valve could not be found.

The outlet of the draw-down pipe at the West Dam is made of dry-laid stone construction and is in good condition.

d. Reservoir Area. Fernwood Lake is bordered by two homes and a manufacturing office building at the north end. Except for the two other dams and the dike mentioned in

Sections 1.2 a and 1.2 b, the shoreline is otherwise undeveloped and generally wooded. The terrain is gentle along the west and slightly steeper on the east. There is no significant probability of landslides into the reservoir affecting the safety of the dam. Sedimentation has apparently not been a problem at the dam site.

e. Downstream Channel. Within its total length of about 2,200 ft., the downstream channel crosses a driveway, a state highway (Route 133), the Boston & Maine Railroad, and a local road before its outfall into the Annisquam River tidal basin.

The concrete apron at the spillway is about 16 ft. long between the sidewalls. The bottom width of the downstream channel varies from about 10 ft. at the beginning of the earth channel to about 5 ft. near the driveway, about 150 ft. downstream of the spillway. Brush and several large trees are growing in the channel just beyond the concrete apron, Photo No. 12. Otherwise, the channel in this reach has a relatively regular and well maintained section with both banks protected by large boulders and large trees, Photo No. 13. The average gradient is about 4 percent. A concrete culvert structure underneath the driveway contains three conduits: one 18-in. diameter, at the center low point of the structure, and two 12-in. diameter pipes about 3 ft. higher. At the time of the site visit, the lower pipe was full of debris and leaves, causing a hydraulic restriction to spillway discharge.

The channel becomes steeper (about 10 percent gradient) downstream of the driveway. Here, the channel course is irregular, and contains large boulders and tree roots overhanging the slopes which were badly scoured during past floods, Photo No. 14. The channel crosses under Route 133 (Essex Avenue) diagonally through a semi-arch shaped and about 60 ft. long culvert. The channel bed is not clearly defined in the swampy area further downstream, between the Route 133 and the Boston & Maine Railroad. The last road crossing is about 1,100 ft. upstream of its confluence with the river.

### 3.2 Evaluation

Based on the visual examination on 6 December 1978, the Fernwood Lake Dam project is considered to be in fair condition. Specific deficiencies noted include the

severe growth of vegetation on most of the downstream slope, indication of seepage at the downstream toe, deteriorating sections of the upstream wall and vegetation in the downstream channel of the spillway. Although the dam is currently performing satisfactorily, the various deficiencies could provide significant potential for embankment failure under conditions of higher than normal water levels or heavy winds.

## SECTION 4 - OPERATIONAL PROCEDURES

### 4.1 Procedures

In general, there are no formal procedures to provide routine maintenance and satisfactory operation of the dam.

The 18-in. diameter draw-off pipe at the West Dam has frequently been used in the past three years to supplement the domestic water supply in Wallace Pond as needed. This has been necessary because another City of Gloucester water supply reservoir, Dykes Pond, has been emptied for repairs. Prior to this recent need for water from Fernwood Lake, the draw-off pipe was rarely operated.

### 4.2 Maintenance of Dam

There are no established procedures or manuals for inspection and maintenance of the dam. Remedial measures such as the cutting of brush are reportedly performed on the basis of demand, although this is not apparent.

### 4.3 Maintenance of Operating Facilities

The spillway structure does not appear to receive regular maintenance. There is no formal plan to maintain the flashboards or the reservoir drain pipe and gate valve control. The discharge channel is not kept free of debris and vegetation.

### 4.4 Description of any Warning System in Effect

There is no warning system or emergency preparedness plan in effect for this structure.

### 4.5 Evaluation

For a structure of this type and classification, an annual observation and maintenance program should be established to examine the dam, control vegetation growth and maintain slopes, walls and channels. A formal procedure should be established for the removal of flashboards during periods of expected high flows.

Since failure of the dam would probably cause loss of life and extensive property damage downstream, the owner should also prepare a formal emergency preparedness plan and warning system.

## SECTION 5 - HYDRAULIC/HYDROLOGIC

### 5.1 Evaluation of Features

a. General. There are four earthfill dams at Fernwood Lake, located at the north, west, east and south. The dam which is under study in this report is the North Dam. Based on the approximate elevations given in Section 1.2, when the water surface elevation rises in the lake it would first overflow the flashboards of the North Dam's spillway at El. 92.3 and then overtop the East Dam at El. 93.4, overflowing into Upper Banjo Pond. Next, the dike at the south end would be overtopped at El. 93.6. The top of the North Dam, El. 95.5, would be overtopped last, after the top of the West Dam at El. 95.4. However, spillway discharge from the reservoir, in general, occurs only for short duration during the spring. The existing valved outlet through the West Dam is used to supplement Wallace Pond, which is a source of water supply for the City of Gloucester.

b. Design Data. No hydrologic or hydraulic design data were available for this dam site.

c. Experience Data. The maximum overflow from the spillway was recorded in December 1968. The water surface at that time reached El. 93.3. This was about 2.3 ft. above the spillway crest, but 2.2 ft. below the top of the dam. The estimated discharge into the downstream channel was about 120 cfs (assuming no flashboards at the crest). During this storm, the first existing downstream culvert, which had a single 18-in. conduit, could not carry the flow. Consequently, the driveway about 150 ft. downstream of the spillway was overtopped, and a large portion of the main access road from Essex Avenue was washed out. Several homes to the north of Essex Avenue were flooded.

d. Visual Observations. The watershed of the pond is heavily wooded. The water surface elevation in the pond was about 2.3 ft. below the spillway crest in early December 1978. However, during a subsequent visit on 4 March 1979, the water level was about 4 in. above the flashboards, and the 18-in. diameter conduit of the culvert underneath the driveway was flowing about half full. The 8-in. diameter draw-off pipe at the spillway was clogged up. Extensive scouring was observed in the channel downstream of the driveway. The channel gradient in this vicinity appears to be quite steep.

The existing 8-in. conduit which was installed at the East Dam in the past to feed into Upper Banjo Pond is permanently blocked. The channel which carries the flows from the West Dam through the woods into Wallace Pond was overgrown with bushes. The water surface elevation at the southern tip of the lake, which was cut off by the South Dike, was about one ft. higher than the water surface elevation in the main lake. Leakage from the cut off pond through another low, short dike (see page B-24) feeds into a swamp which, in turn, flows towards Wallace Pond. An old pump station, left from the Cape Pond Ice Company time, is located at this end of the lake.

e. Test Flood Analysis. Based upon the Corps of Engineers guidelines, the recommended test flood for the size "small" and the hazard potential "high" is within the range of 1/2 PMF to PMF (Probable Maximum Flood). The PMF was determined using Corps of Engineers Guidelines for Estimating Maximum Probable Discharge in Phase I Dam Safety Investigations. The watershed terrain was determined to be midway between flat-coastal and rolling, and an inflow rate of 1,825 cfs per square mile was interpolated for the drainage area of 0.52 square miles. The resulting PMF inflow is 950 cfs.

The 1/2 PMF inflow of 475 cfs was adopted as the test flood for this investigation. Surge-storage routing was performed through Fernwood Lake using the related stage-discharge and area-volume curves which are shown in Appendix D. The piped outlets at various points of the lake were assumed to be closed for this evaluation.

Condition 1: 1.3 ft. flashboards are assumed to be left in place; the test flood outflow, which was estimated to be 370 cfs, would occur when the water surface elevation in the pond is 93.9. The East Dam and the South Dike would be overtopped by about 0.5 ft. and 0.3 ft., respectively, at this stage.

Condition 2: There are no flashboards at the spillway; the test flood outflow of about 300 cfs would occur at pond elevation 93.8. At this stage the East Dam and South Dike would be overtopped by 0.4 ft. and 0.2 ft., respectively.

Under Condition 1, flow over the spillway would be 150 cfs, with the remaining flow of 220 cfs over the East Dam and South Dike. Under Condition 2, 160 cfs would flow over the spillway, with the remaining 140 cfs over the East Dam and South Dike.

It is concluded that the spillway of the North Dam is not adequate to pass the test flood without overtopping the East Dam and South Dike embankments, although the North Dam embankment would not be overtopped. It also appears that the downstream channel does not have adequate capacity.

f. Dam Failure Analysis. Based on Corps of Engineers Guidelines for Estimating Dam Failure Hydrographs and assuming that a failure would occur along 40 percent of the length of the dam embankment, the peak failure outflow is estimated to be 22,000 cfs. The capacity of the channel downstream of the dam is insufficient to carry this much flow.

The flood water would flow over steep woodlands towards Route 133 and to the low lying areas along the downstream channel of the spillway. It is estimated that four single family homes and a garage-repair shop on the northern side of Route 133 (Essex Avenue), and seven single family homes, which are located beyond the Boston & Maine Railroad tracks, to the north, would be flooded with about 8 ft. of water. Depending on the location of the failure section along the embankment, a home at about 50 feet west of the spillway, at the toe of the dam, and the driveway connecting the spillway and the two nearby homes to Route 133 could also be subject to flooding. There would not be any substantial flooding in the downstream area immediately prior to failure.

Therefore, it can be concluded that an overall potential for loss of life and excessive property damages exists at this dam site, and the hazard potential classification is considered high.

## SECTION 6 - STRUCTURAL STABILITY

### 6.1 Evaluation of Structural Stability

a. Visual Observations. There was no visual evidence of major settlement, lateral movement or other obvious signs of structural instability in the earth embankment. The slight variation in the vertical alignment of the crest may reflect either how the embankment was originally graded, or settlement. The deterioration of sections of the upstream wall does not appear to be the result of lateral movement of the embankment. Several wet areas that were noted below the downstream toe of the embankment are indicative of a seepage condition that could worsen with normal and high lake levels.

The spillway structure, in general, is in good condition. No movement or distress that would indicate structural instability was noted, and the spillway structure is therefore considered to be structurally stable under normal static loading conditions.

b. Design and Construction Data. There are neither design drawings nor construction data which would show the embankment cross-section and the physical properties of the materials used to construct the embankment in 1877. Therefore, a theoretical analysis of the embankment stability is not possible.

Design data in the form of drawings of the spillway construction dated 1929 are available. Review of the drawings indicate that the dimensions and configuration of the spillway are consistent with typical spillways of this size. Since no movement or distress has been observed, it is concluded that the spillway is currently stable.

c. Operating Records. There is no instrumentation installed at the dam site to aid in the stability evaluation. State and county inspection reports were located which document the general performance of the dam for some 60 years. No significant problems with the operation of the dam were reported.

d. Post-Construction Changes. Review of the available engineering data indicates that in 1929 the spillway and the upstream wall of the embankment were constructed and the embankment was raised approximately two ft. These

modifications were apparently intended to increase the resistance of the embankment to damage by wave action and overtopping.

e. Seismic Stability. Fernwood Lake Dam is located in a Seismic Zone 3. Settlement of the crest and downslope movements during a seismic event are a function of foundation soils below the embankment and properties of embankment materials. Pertinent data needed for a theoretical seismic stability analysis of the embankment are not available. Therefore, the stability of the embankment during an earthquake is unknown.

It is likely that the upstream wall of the dam would suffer damage under seismic loading conditions, but this alone would not cause immediate failure of the dam. With regard to the spillway, it should be noted that the spillway has a nearly-buried concrete weir and a grouted stone masonry downstream apron. Wooden flashboards extend about 1.3 ft. above the weir. Because of its low height, therefore, failure of the spillway weir and flashboards is not likely to be a catastrophic event. Failure of the spillway walls would expose the embankment to damage.

## SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

### 7.1 Dam Assessment

a. Condition. The visual examination of Fernwood Lake Dam revealed that the structure was in fair condition. Although there were no signs of impending structural failure or other conditions which would warrant urgent remedial action, several deficiencies were noted.

Based on the results of computations included in Appendix D and described in Section 5, the spillway is not capable of passing the 1/2 PMF test flood, which has an inflow of 475 cfs (913 csm), without overtopping dams at other locations on Fernwood Lake. With the water level at the top of Fernwood Lake Dam, the spillway capacity with flashboards is 370 cfs. The test flood outflow of 370 cfs would overtop East Dam and South Dike by 0.5 ft. and 0.3 ft., respectively, although a freeboard of 1.6 ft. would remain at Fernwood Lake (North) Dam. With the water level at the top of East Dam (lowest dam on lake), the spillway capacity with flashboards is about 80 cfs or 22 percent of the peak test flood outflow.

b. Adequacy of Information. This evaluation of the dam is based primarily on visual examination, preliminary hydraulic and hydrologic computations, consideration of past performance and application of engineering judgement. Generally, the information available or obtained was adequate for the purposes of a Phase I assessment. However, it is recommended that additional information needed to assess the seismic stability of the dam, as outlined in Section 7.2, be obtained.

c. Urgency. The recommended additional investigations and remedial measures outlined in Sections 7.2 and 7.3, respectively, should be undertaken by the Owner and completed within one year after receipt of this report.

d. Need for Additional Investigations. Additional investigations should be performed by the Owner as outlined in Section 7.2.

### 7.2 Recommendations

It is recommended that the City of Gloucester, owner of the dam, engage a registered professional engineer

experienced in earth dam design to undertake the following investigations:

1. Investigate methods to increase discharge capacity of the dam or determine the height to which other dams on the lake must be raised in order to pass the test flood without overtopping any other dams on Fernwood Lake.
2. An investigation to determine whether or not the seepage that is occurring at the downstream toe of the dam can have a significant effect on long-term dam stability. This would include regular monitoring of the various observed seepage locations, including checks during higher than normal pond levels, to determine if conditions are changing with time.
3. Assess the potential for a failure of the dam embankment under earthquake loading conditions for Seismic Zone 3.

The Owner should then implement corrective measures on the basis of this engineering evaluation.

### 7.3 Remedial Measures

The dam is generally in fair condition, and it is considered important that the following items be accomplished:

a. Operation and Maintenance Procedures. The following should be undertaken by the City of Gloucester, in addition to the investigation outlined in Section 7.2, to correct deficiencies noted during the visual examination:

1. Clear the upstream and downstream slopes of the embankment of trees, brush and debris. After clearing, examine the embankment for evidence of animal burrowing activity and seepage. Remove stumps and major roots and place fill to restore the embankment cross-section. Establish and maintain vegetative cover on the downstream slope and cut growth at least once a year.
2. Repair local eroded areas in the embankment and establish turf to resist erosion where it is bare on the crest. If foot traffic is unrestricted and does not permit such a growth, the trafficked

areas should be protected by pavement or other means.

3. Repair the upstream wall where it has partially collapsed.
4. Clear brush, trees and debris in the downstream channel between the spillway and Essex Avenue which presently are hydraulic restrictions to spillway discharge.
5. Prepare an operations and maintenance manual for Fernwood Lake (North) Dam. The manual should include provisions for annual technical inspection of the dam and for surveillance of the dam during periods of heavy precipitation and high reservoir water levels. The procedures should delineate the routine operational procedures and maintenance work to be done on the dam to ensure satisfactory operation and to minimize deterioration of the facility, and include a formal procedure for removal of flashboards during periods of expected high flow.
6. Because Fernwood Lake (North) Dam is classified as having a "high" hazard potential, develop a written emergency preparedness plan and warning system to be used in the event of impending failure of the dam. The plan should be developed in cooperation with local officials and downstream inhabitants.

#### 7.4 Alternatives

Not applicable.

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

Dam: Fernwood Lake

Date: 6 December 1978

Time: 1345-1630

Weather: Sunny, 50°F

Water Surface Elevation Upstream: El. 88.7 (2.3 ft. below  
top of concrete  
spillway weir)

Stream Flow: No flow over spillway

Inspection Party:

Peter L. LeCount  
Richard A. Brown  
Haley & Aldrich, Inc.

- Soils/Geology

A. Ulvi Gulbey  
Joseph E. Downing

- Hydraulic/Hydrologic

Robert P. Howard  
Camp, Dresser & McKee, Inc.

- Structural/Mechanical

Present During Inspection:

Wilford E. Burke, Chief Operator  
City of Gloucester, Public Works Department

# **VISUAL INSPECTION CHECK LIST** **NATIONAL DAM INSPECTION PROGRAM**

**DAM:** Fernwood Lake Dam

**DATE:** 6 Dec. 78

AREA EVALUATED	CONDITION
<u>DAM EMBANKMENT</u>	
Crest Elevation	Top of concrete spillway walls is 3.7 ft. above spillway crest or El. 94.7. Adjacent capstone at El. 95.5 and top of embankment at El. 96.0. Capstone and embankment near left abutment at approximately El. 95.3
Current Pool Elevation	El. 88.7 (2.3 ft. below spillway crest)
Maximum Impoundment to Date	Mark on left spillway wall dated 20 March 1968 is 2.3 ft. above spillway crest or El. 93.3
Surface Cracks	None observed
Pavement Condition	None, surface is grass and weeds with dirt path
Movement or Settlement of Crest	None apparent, slightly irregular
Lateral Movement	None now apparent, reason for repair of short section of upstream wall not known
Vertical Alignment	Fair, crest elevation varies by nearly 1 ft.
Horizontal Alignment	Fair, several wall capstones dislodged
Condition at Abutment and at Concrete Structures	Satisfactory at spillway, grades into rock at left abutment
Indications of Movement of Structural Items on Slopes	Upstream wall capstones have moved locally, portion of wall repaired
Trespassing on Slopes	Foot traffic on crest, trash dumped on downstream slope
Animal Burrows in Embankment	None observed
Vegetation on Embankment	Except at the house, downstream slope is obscured by brush, young trees, brambles, dumped tree and brush cuttings and trash
Sloughing or Erosion of Slopes or Abutments	None apparent except small gully in downstream slope 45 ft. from left abutment

FILE NO. 4160

# **VISUAL INSPECTION CHECK LIST NATIONAL DAM INSPECTION PROGRAM**

**DAM:** Fernwood Lake Dam

**DATE:** 6 Dec. 78

AREA EVALUATED	CONDITION
<p>Rock Slope Protection - Riprap Failures</p> <p>Unusual Movement or Cracking at or near Toes</p> <p>Unusual Embankment or Downstream Seepage</p> <p>Piping or Boils</p> <p>Foundation Drainage Features</p> <p>Toe Drains</p> <p>Instrumentation Systems</p> <p><u>OUTLET WORKS - SPILLWAY</u> <u>WEIR, APPROACH AND</u> <u>DISCHARGE CHANNELS</u></p> <p><u>a. Approach Channel</u></p> <p>General Condition</p> <p>Loose Rock Overhanging Channel</p> <p>Trees Overhanging Channel</p> <p>Floor of Approach Channel</p> <p><u>b. Weir and Training Walls</u></p> <p>General Condition</p> <p>Rust or Staining</p> <p>Spalling</p> <p>Any Visible Rein- forcing</p>	<p>Upstream face has vertical stone masonry wall, capstones locally dislodged</p> <p>None observed</p> <p>Local small areas with water at ground surface 10-15 ft. from down- stream toe, no evidence of soil movement</p> <p>None observed</p> <p>None known</p> <p>None known</p> <p>None</p> <p>Good</p> <p>None observed</p> <p>None observed</p> <p>Natural ground with small rock debris</p> <p>The 16-ft. long grouted masonry apron is in good condition. The apron is partially silted over and supporting a heavy growth of grass. The side walls are of con- crete construction and in good condition</p> <p>Some staining observed on the training walls</p> <p>Some minor spalling observed on walls upstream of weir</p> <p>None observed</p>

FILE NO. 4160

HALEY & ALDRICH, INC.  
CAMBRIDGE, MASSACHUSETTS

A-3

# **VISUAL INSPECTION CHECK LIST** **NATIONAL DAM INSPECTION PROGRAM**

DAM: Fernwood Lake Dam

DATE: 6 Dec. 78

AREA EVALUATED	CONDITION
<p>Drain Holes</p> <p>Flashboards</p> <p>c. <u>Discharge Channel</u></p> <p>General Condition</p> <p>Loose Rock Overhanging Channel</p> <p>Trees Overhanging Channel</p> <p>Floor of Channel</p> <p>Other Obstructions</p> <p>Handrails</p> <p>Other</p>	<p>None observed</p> <p>Good condition</p> <p>Good - there are some brush and trees in the channel. Channel walls are stone masonry in good condition</p> <p>None observed</p> <p>Some observed along the channel</p> <p>Natural ground</p> <p>None observed</p> <p>Pipe handrails on spillway walls are in good condition; one pipe support on the right wall is supported by a concrete block only. There are only top rails making up the handrail</p> <p>There was a valve box observed upstream of the spillway near the right wall. The pipe inlet and outlet cannot be found</p>
<u>OUTLET WORKS ~ WEST DAM</u>	
<p>General Condition</p>	<p>The outlet of the drain down pipe at the West Dam is made of dry laid stone masonry construction and is in good condition. The inlet was submerged. There is a gate valve in a manhole in the road adjacent to the dam</p>

FILE NO. 4160

HALEY & ALDRICH, INC.  
CAMBRIDGE, MASSACHUSETTS

A-4

## APPENDIX B - ENGINEERING DATA

	<u>Page</u>
<u>LIST OF AVAILABLE DATA</u>	B-1
<u>LIST OF SUPPLEMENTAL DATA</u>	B-2
<u>PRIOR INSPECTION REPORTS</u>	
Essex County inspection report dated 23 April 1912 and summary of 26 inspections from 1917 through 1969	B-3
Report and Record of Inspections in Connection with Raising Dam and Building New Spillway in 1929 by the Essex County Engineer	B-8
State inspection report dated 7 July 1971	B-21
<u>DRAWINGS</u>	
Plan and Sections of Proposed Spillway, 5 September 1929, John H. Griffin, Engineer	B-23
Plan of Land in West Gloucester, 4 February 1952 (with the locations of other dams on Fernwood Lake added to the drawing)	B-24
<u>SUPPLEMENTAL INSPECTION REPORTS</u>	
Essex County inspection report dated 24 April 1912 and summary of 25 inspections from 1917 through 1969 of the West Dam (D.7) along the southwest shoreline and also the South Dike across the south end of Fernwood Lake	B-25
State inspection report on the West Dam dated 7 July 1971	B-31
Essex County inspection report dated 24 April 1912 and summary of 22 inspections from 1917 through 1966 of the East Dam (D.8) at outlet to Upper Banjo Pond	B-33

U 100-3-C  
D. 9 R. S. P.

COUNTY OF ESSEX, MASSACHUSETTS  
ENGINEERING DEPARTMENT

Inspection of Dams, Reservoirs, and Stand Pipes

0 108-5C  
SUB NUMBER  
D. 9 R. S. P.  
Neg. No. 491

Inspector C. C. Barker Date April 23 1912 \*Classification 2

City or Town Gloucester Location North end of Fernwood Lake

South East of Essex Ave

Owner Cape Pond Ice Co. Use Ice Pond

\*Include such details as core, cut of wall, paving, bedding, class of masonry, kind of cement (nat. or port.) etc.

Material and Type Earth & Stone paved on the upper side with small & large field stone

Elevations in feet: above (+) or below (-) full pond or reservoir level. (Cross out what does not apply.)

For Dam  
Bed of stream below Bottom of pond Bottom of spillway Top of dam Top of flash boards  
For Res. or S. P.  
Ground surface below Bottom of res. Level of over-flow pipe Top of res.

For dam Length in ft. 700 Top width in ft. 12 Pond area 20<sup>±</sup> acres Area of watershed 4<sup>±</sup> sq. mi.

For Res. or S. P.  
Inside dimensions Capacity Covered type

Length of overflow or spillway Outlet pipes (size and nature)

Stand pipe, thickness at base Diameter of rivet head Pitch

Foundation and details of construction

Constructed by and date F. W. Hornum owned this dam in 1877 probably built by him

Recent repairs and date

Evidence of leakage Ground below is wet and there is some leakage

Condition F. G. I. C. S. P. valves painted

Topography of country below Open valley

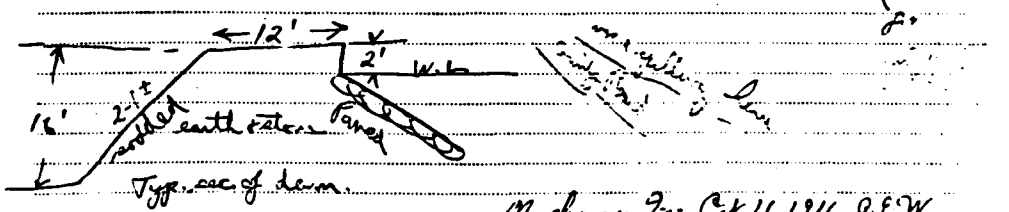
Nature, extent, proximity, etc. of buildings, roads or other property in danger if failure should occur No houses

A machine shop and a street might be damaged

Plans and data secured or available

Use separate sheet for sketches if necessary. Notes, sketches, sections, etc.

The dam is 16 ft high with side slopes a little less than 2 to 1. There is no overflow but there is a draw-off pipe + gate upper end protected by timber. Lower end covered with stones



Mochnager Ins. Oct 16 1916 R. E. W.

\*Classify as to probable damage in case of failure. 1 slight. 2 moderate. 3 serious.

Gloucester D. 9

1917, March 26. Watershed 0.5 sq. m. Max. Ht. 16.0 ft. Apparent condition, Fair.

1925, Oct. 29. R. R. Evans, Insp. There are three separate dams forming Fernwood Lake, all belonging to the Cape Pond Ice Co. On the west side of the pond is the dam of greatest height, an earth dam about sixteen feet high at the highest point. It is in fairly good condition. The land below it is wet and swampy, probably, in part at least, due to seepage, and a low valley extends northward across Essex Ave. in the vicinity of the garage on the westerly side near the Railroad crossing. No well planned provision has been made for a waste way. Except for the pipes through the dams at the northerly and easterly ends of the pond, there is now no waste way except a small culvert at the southerly end which has very little capacity. Apparently the draft on this pond is heavy and flood discharge is small. Apparently, also, any over flow would find its way from the north east end of the pond without serious damage, but the dam at the westerly side is of sufficient height to release a flood wave of magnitude in case of failure, and considerable damage might be done to the road as well as the garage and the Railroad near the low point. There was formerly a waste way at the north dam but this has been filled in. Something else should be provided, and west dams should be raised to guard against damage by waves.

1925 Report to Co. Comm. Same as above.

1928, Oct. 5. C. C. Barker, Insp. Dam at the north end of Fernwood Lake, is owned by the Cape Pond Ice Company, and the pond is used for cutting ice. I gave a copy of the notice to E. Raymond Abbott, Supt., who went to the dam with me. In case of failure there would be some damage to the main highway below this dam, also to a machine shop. There would probably not be any loss of life. The dam is in good condition and there have been no changes since the last inspection, except that large sponges have been put along the upper face to prevent wave action on the earth slopes. The old eight inch draw off pipe at this dam has been clogged up and is not in use now. Today the pond is full. Mr. Abbott has a night watchman who is on duty all the time to see that the gate on dam #8 is opened when the water rises above a certain level. However, on this pond there should be a large enough spillway to take care of the over-flow automatically.

1928, Nov. 30. R. R. Evans, Insp. See D. 7 ✓

1928 Report to Co. Comm. See D. 7 - 1928 Report

1929, Sept. 9. R. R. Evans report to Co. Comm. on proposed spillway for Fernwood Lake Dams. See 0354C - 1929

1929, Dec. 23. R. R. Evans report on completion of work approved by the Co. Comm. Sept. 10, 1929, See 0354C - 1929

1929 Report to Co. Comm. Following several conferences with the owners of the Cape Pond Ice Company, they made application for approval of plans and specifications for alterations and repairs to their dam at Fernwood Lake in the city of Gloucester, and the plans and specifications were approved and work has been substantially completed in accordance therewith, although some loaming and seeding will probably be done in the coming year. As recommended in previous reports, this dam is now

Gloucester, D. 9

provided with a suitable spillway which was built in the solid ground at the easterly end of the main dam. The head walls of this spillway and the top of the earth embankment have been carried to an elevation about two (2) feet higher than the former top of the dam, so that with the spillway and this added protection against the wash of the waves, the dam would seem to be safe under any conditions which may reasonably be expected to occur. The dam at the east end of the pond was not raised since it is such a low affair and the slope below it so flat that any overflow which might occur would not do serious damage. In raising the embankment, the owners elected to build a rough stone wall of dry rubble along the face of the dam next the water for the entire length from the spillway southwesterly. The foundation of this wall is about two (2) feet lower than the spillway, not below probable frost action, so that the wall will be more or less affected by such action, but although this may necessitate repairs from time to time, the wall gives an added protection against the wash of the waves and an added width to the top of the dam, both of which are beneficial.

1930, Sept. 16. C. C. Barker, Insp. Dam at the north end of Fernwood Lake, is owned by the Cape Pond Ice Company. This pond is used for cutting ice. I gave a copy of the notice to E. Raymond Abbott, Supt. No one inspected the dam with me. In case of failure, there would be damage to the roadway below the dam and probably a garage. It is not likely there would be any loss of life. Since the last inspection, a good spillway has been built at the east end of this dam, a plan of which is in the County Engineer's office. This dam has been raised. A dry faced wall has been built along the inner face of the dam. This dam is in good condition now. The water level is 4 inches below the spillway. Note: The outlet at the southwesterly end of this pond has been nearly closed, leaving an opening of 2.5 feet wide by 2 inches deep. The top of the outlet is about 2 inches above the flash board of the new spillway at the other end of the pond.

1930 Report to Co. Comm. See D. 7 - 1930 Report.

1932, Aug. 2. C. C. Barker, Insp. The dam is in good condition. There has been no change and conditions are the same. The water level is about 3 inches below the concrete spillway.

1932 Report to Co. Comm. Safe and in reasonably good condition.

1934, Sept. 28. C. C. Barker, Insp. This dam is in good condition. There is a good face wall, not cemented, along the upper side. The water level is about 3 inches below the spillway. There has been no change.

1934 Report to Co. Comm. Safe and in reasonably good condition.

1936 August 10, C.C.Barker, Insp. This dam is in good condition. There is a slight seepage at the base of the high section of the embankment. There has been no change. Water level 1" below the concrete spillway.

1936 Report to Co. Comm. Safe and in reasonably good condition.

1938 October 26, C.C.Barker, Insp. This dam is in good condition and there has been no change since the last inspection. The water level is 3.5 feet below the top of the dam and is just spilling over the stop plank.

Gloucester D. 9

1938 Report to Co. Comm. Safe and in reasonably good condition.

1940 Oct. 4, C.C.Barker, Insp. This dam is in good condition. There has not been any change. The water level is at the spillway grade.

1940 Report to Co. Comm. Safe and in reasonably good condition.

1942 Aug. 3, C.C.Barker, Insp. This dam is in good condition, and there has not been any change. The pond is full.

1942 Report to Co. Comm. Safe and in reasonably good condition.

1944 July 26, S.W.Woodbury, Insp. I gave a copy of the notice to Mr. Abbott, but visited the dam alone. Water level is 0.4 ft. over the lip of the spillway and is held back by a 4 inch plank 9 inches high. Concrete and paving at the spillway is in good condition.

1944 Report to Co. Comm. Safe and in reasonably good condition.

1946 Sept. 24, S.W.Woodbury, Insp. Still owned by the Cape Pond Ice Co. (changed hands, however). Mr. John Ryan is now in control. I gave a copy of the notice to Mr. Albert Tebo who is in charge of the Ice House and went to dam alone. Water level today is 2.8' below top of concrete sidewall of spillway. Condition is same.

1946 Report to Co. Comm. Safe and in reasonably good condition.

1948 Sept. 30, S. W. Woodbury, Insp. Gave a copy of the notice to Mr. Sundback for Mr. Tebo and went to dam alone. Further inspection is needed to see that spillway is cleaned out. Water level today: 4.5' below top of sidewall of spillway. The northerly end of the wooden bridge over the spillway has collapsed and is blocking the spillway. This should be removed at once as another storm like the one of Dec. 7, 1945 might cause serious damage. The ice house is being demolished by the Danvers Wrecking Co. A portion which remained standing burned down on Sept. 28, 1948.

1948 Report to Co. Comm. At the northerly end of Fernwood Lake, the spillway in the dam near the ice houses, which are being demolished, is obstructed by the bridge which has collapsed. This obstruction should be removed and the spillway kept clear.

1950 Sept. 27, S.W.Woodbury, Insp. Gave a copy of the notice to Mr. Tebo and went to the dam alone. The bridge over the spillway has been repaired. Water level today: 6.0 below top of conc. sidewall of spillway. Condition of the dam is the same.

Safe and in reasonably good condition.  
1950 Report to Co. Comm. ~~Gloucester D. 9, Sh. 3~~

1952 Sept. 24, E.H.Page, Insp. City of Gloucester (Water Works) new owner. Gave a copy of the notice to Mr. Hull at Water Dept. and went to dam alone. Water level today: 4.6 ft. below conc. side wall at spillway. A lot of debris in the spillway.

Gloucester D. 9

1952 Report to Co. Comm. Safe and in reasonably good condition.

1954, May 28, E.H. Page, Insp. Elev. of water: 1 1/2" over flashboards. Height of flashboards: 1'-5". Minimum freeboard with all possible stop logs etc. in place: 2'-6". Entrance to spillway completely full of debris. Debris should be cleaned out. Granite wall northwesterly of spillway is tipping out a little.

1954 Report to Co. Comm. Safe and in reasonably good condition.

1956 Sept. 13, E.H. Page, Insp. Elev. of water: 14" below top of flashboards. Height of flashboards: 15". Obstructions: Debris both sides of flashboards.

1956 Report to Co. Comm. Safe and in reasonably good condition.

1958, Dec. 30, E.H. Page & K.M. Jackson, Insp. Elev. of water: 1" Height of flashboards 15". Debris up against flashboards.

1958 Report to Co. Comm. Safe and in reasonably good condition.

1961 January 12, E.H. Page and P.D. Killam, Insps. Elev. of water: 1/2 inch water over flashboards. Height of flashboards: 1'. Bushes in spillway.

1960 Report to Co. Comm. Safe and in reasonably good condition.

1962 Dec. 17, K.M. Jackson, Insp. Owner: City of Gloucester Water Works. Elev. of water: Even with spillway. Height of flashboards: 12' x 12' x 10' Obstruction in spillway: Filled with debris. Condition of dam: Same as 1960 report.

1962 Report to Co. Comm. Fernwood Lake, north end. There is debris in spillway that should be cleaned out.

1964 Dec. 29, P.D.K. & K.M.J., Insps. Debris in spillway should be removed.

1964 Report to Co. Comm. Debris in the spillway should be removed.

1966 April 17, 1967. P.D.K. & K.M.J., Insps. Debris in spillway should be removed.

1966 Report to Co. Comm. Bridge crossing outlet has fallen into outlet. This should be removed and the outlet cleared.

1968 March 26, 1969, P.D. Killam and J. Fitzgerald. The spillway is clear of debris with 0.2 ft. water going over flashboards.

0354C

1929

FERNWOOD LAKE DAM, GLOUCESTER, MASS.

Report and Record of Inspections in Connection  
with Raising Dam and Building New Spillway

1929

September 9, 1929.

To the Commissioners of Essex County:

Gentlemen:

I submit herewith the following report in regard to proposed work at Fernwood Lake in the city of Gloucester to provide a suitable spillway for the protection of the dams.

Following your communication sent to the Cape Pond Ice Company under date of May 6, 1929, calling their attention to the recommendations contained in my report to you upon the matter, I have several times been in consultation with the representatives of the Cape Pond Ice Company and with their Engineer, Mr. John E. Griffin of Gloucester to discuss the matter. Excavations to determine the foundation material to be encountered have been made by Mr. J. S. Pomeroy, Contractor, in behalf of the Cape Pond Ice Company, and this excavation was made over the full extent of the proposed spillway which is to be located in the dam at the north end of the pond a short distance west of the ice house, at an old water course where a spillway formerly existed.

I visited the dam on August 27 and met the Contractor and the Engineer, together with Mr. Abbott, representing the Ice Company. We inspected the excavation which had at that time been completed to the grade of the bottom of the concrete dam proposed by the Engineer. Apparently this excavation was in the natural ground which is a compact clay gravel and fairly hard. At my suggestion, a cut-off trench along the center of the dam was excavated about a foot deeper and I think that the material at this depth is satisfactory for a dam of the proposed height, which is very little above the natural surface.

A plan of the proposed dam or spillway, dated September 5, 1929, incorporating such changes as I have suggested, has now been submitted to me by Mr. Griffin and this plan calls for a concrete spillway twenty (20) feet in length, four and one-half (4 1/2) feet below the proposed level of the top of the earth dam which is to be raised about two (2) feet. Flash boards twelve (12) inches in height are provided to hold the water at substantially the same level at which it has been normally maintained in the past, so that the top of the earth dam when completed will be three and one-half (3 1/2) feet above the normal level of the pond and this would probably be sufficient for any conditions of run-off and wave action which can reasonably be anticipated on this pond, but by the removal of the flash boards further protection can be obtained.

The water in the pond is at present very low and the owners, in order to take advantage of this fact, have proceeded on their own responsibility with the construction of the dam according to the plan

- 2 -

County Commissioners

9/9/29

as now submitted, and I have made such inspections either personally or through an assistant as seemed necessary, but no work so far done by the company has been authorized by me, and it is understood that the work must in any event conform to the requirements of the Commissioners.

I would recommend that the plan be approved, and as no specifications are submitted for approval, I would recommend that the quality of workmanship and of materials, and all details of construction be subject to the approval of this department.

Respectfully submitted,

County Engineer.

2/A-3

B-10

#### FERNWOOD LAKE DAM

Met Mr. Abbott of the Cape Pond Ice Company at their office 3:00 P. M., May 13, 1929, and visited the dam at the north and northwest sides of the pond. We discussed best location for a spillway, and Mr. Abbott feels it would be best to maintain it in the original location at the east end of the dam nearest the ice house. The Company, he says, does not own the land through which the overflow from this spillway would find its way, but have a right to discharge the water through this channel which is partially walled in. It would apparently be possible to get the entire spillway in the original surface outside the fill, and we discussed many possibilities in the arrangement of this spillway. I told Mr. Abbott that I should much prefer that his own engineer would submit a design for our approval, rather than that we should furnish the design to them, but that I am willing to co-operate in every way with that engineer and make any suggestions which he may desire. He states that he will have Mr. Griffin of Gloucester get in touch with me and prepare such a design.

As to the probable length of spillway needed, I have told him that roughly speaking, it should be from 15 to 20 feet in length and at least 4 feet below the top of the earth embankment, but before stating definitely the exact dimensions we should know the area of the water shed, which is not known at all accurately at the present time. Before leaving the dam, Mr. Abbott introduced me to Mr. Romans who has been with the Company for many years. Mr. Romans says that there is a masonry wall in the dam extending up to the old spillway, and I have suggested to Mr. Abbott that one of the first things to be done would be to excavate and find the top of this wall. He feels that the pond level should be maintained as high as at present, which means that a height of 4 feet above the spillway must be secured by raising the earth embankment.

FERNWOOD LAKE DAM

July 2, 1929 met Mr. Griffin and Mr. Abbott at Fernwood Lake at 2:00 P. M. Went over ground carefully and discussed many possibilities, and it was finally left that Mr. Griffin would make a survey and plan of the locality and will get in touch with me the first of next week to arrange to bring this plan to Salem and discuss further a proposed structure.

FERNWOOD LAKE, GLOUCESTER.

Proposed Changes in Dam.

August 27, 1929, met Mr. Griffin, Mr. Abbott and Mr. Pomeroy, the Contractor, at about 3:00 P. M. at the dam. Excavation to determine character of the bottom has been made over practically the entire area of a spillway to give twenty foot clear width. The portion next the water has not been excavated. The bottom which has been uncovered is some two or three feet below the present level of the pond, which is low, and this bottom is practically dry showing no seepage from beneath and very little from the side of the excavation next the pond. Tested with a bar, the bottom is somewhat soft for a foot or more, so that I have recommended that a cut-off trench twelve or fifteen inches wide and at least a foot deep should be excavated longitudinally of the dam at about the center. Mr. Griffin has a rough sketch showing proposed general outlines for the spillway, and this was discussed and it is agreed that he will make some alterations and submit a complete plan to me as soon as possible, as I have told them that I have no authority to tell them to go ahead on the work, but can merely recommend to the Commissioners that the plan be adopted. Apparently they will take the chance of going ahead without waiting for approval by the Commissioners, and I have told them that I will have someone on the ground Friday, the 29th, when it is expected they will be ready to pour concrete. The question of reinforcing rods was discussed and it is agreed that they will put in a grillage of one-half inch rods about twelve inches on centers both ways as temperature reinforcement, not enough to do any particular good otherwise. Various arrangements for flash boards were discussed, and it is decided to leave concrete piers with a wooden block on the water side so that flash boards may be nailed to these blocks sufficiently to hold them in place, but not enough to prevent prompt removal.

September 4, 1929, was at the dam about 8:15 A. M. Mr. Barker was also there and had been there yesterday. Forms are in place and some concrete

has been poured in the bottom of the forms. Mr. Griffin has not as yet submitted plan. The concrete is a little too wet and the gravel from which it is made contains much disintegrated granite, some of which can be broken up with the fingers, and I tried to get in touch with Mr. Pomeroy but was not successful in meeting him before leaving, but have sent word to him that the gravel is unsatisfactory and have asked him to get in touch with Mr. Barker about it. Laitance does not seem to have been removed from the top of the concrete deposited yesterday, and I am doubtful whether there will be much of a bond. This joint comes below the ground surface on all sides so that I do not anticipate that it will cause any trouble.

September 9, visited the dam about 8:30. Found workmen removing the forms. Saw Mr. Abbott and impressed upon him the necessity of having some large stone removed from back fill and having material rammed in thin layers well moistened. He will attend to this matter himself. Talked with Mr. Griffin later about some changes in plan he has submitted, and he authorizes me to make these changes on the plan.

September 11, was at the dam about noon, and find that the back fill has been partially completed. Apparently my instructions are being fully carried out, and material seems to be very thoroughly compacted.

FERNWOOD LAKE DAM, GLOUCESTER.

New Spillway.

August 30, 1929.

I was at Fernwood Lake Dam this morning where a new spillway is being built by J. S. Pomeroy for Cape Pond Ice Company. Four men were working on the forms. Some of the reinforcement was in place. The foundation is very hard - earth somewhat clayey.

In the upper side near the drawoff pipe near the easterly side, there is a slight leak through the ground. The water probably follows along the old pipe which is left in place. This water (which is only a small quantity) is pumped back into the pond.

Mr. Pomeroy and Mr. Abbott were at the work.

September 3, 1929.

Five men were at the job this morning nearly ready to pour concrete. I found that the westerly wall was to be six (6) inches lower than the easterly wall, and the bridge was to be built on a grade, which would cut down the head room over the spillway. Mr. Evans said that he wanted at least 2' 6" clear depth between the top of the flash board and the bottom of the bridge beams. I took this matter up with Mr. Pomeroy and Mr. Abbott, who said to build up the forms so as to get the required depth and make the bridge level. I had them pump out what little water was in the trench and clean off the bottom, which was hard clayey material. They began to pour concrete at 11:30 A. M., using one bag of Vulcanite cement to 30 shovels of sand and gravel, giving about 1:5 concrete. The sand and gravel was as it came from the pit. They stopped work at 4:00 P. M. Small stones were put in the top of the concrete for dowels.

September 4, 1929.

At 7:00 A. M. five men began concreting. Mr. Evans was at the work this morning. A thin mixture was used at first so as to get a good bond to old concrete. At 4:30 when I left the work, the east wall and

spillway was finished, the west wall was within about one foot of the top.  
Mr. Pomeroy was there to see that the concreting would be finished.  
About 250 bags of cement were used.

C.C.B.

#### FERNWOOD LAKE DAM.

September 16, I visited the dam with Mr. Abbott. The Contractor has left the work and everything seems to be in first class shape so far as the dam is concerned. The paving seems to have been done in accordance with our requirements. The spaces between the paving are filled with broken stone and Mr. Abbott tells me that the large stone are at least a foot in depth with broken stone below them. I know from my observation that the sub-grade was shaped up to permit of this. Nothing has as yet been done toward raising the top of the earth dam, but Mr. Abbott states that it is his intention to go at that very shortly and do it with his own men.

September 27, I visited the dam about 8:00 A. M. and found the men at work laying up a dry wall on the side next the water from the spillway southwesterly. Some 30 or 40 feet of wall has been laid and fill is being made behind it near the spillway. A wooden bridge has been completed over the spillway and some fill has been made on the top of the dam beyond this point. Material used in this fill is excellent and has packed down very hard. Mr. Homans says that grubbing hoes were used to remove the sods and there is no evidence that much was done in this direction as the sods do not seem to appear on the slopes where they were presumably disposed of. The fill near the spillway is silty and has been deposited in too deep a layer. I called this to the attention of Mr. Homans and I think he will take care of it.

September 30, 4:30 P. M. work of laying up wall was continuing and some more fill has been made. Material in fill near spillway seems to be coming better and compacts very well.

#### FERNWOOD LAKE DAM.

About October 24, 1929, I visited the dam late in the afternoon on or about this date, and met Mr. Abbott. He has nearly completed the stone wall for the entire length of the dam from the spillway southwesterly. We went through the woods to the second dam and discussed the problem of raising this dam also. Mr. Abbott does not know where he is going to obtain material and he maintains that there is no feasible way of getting trucks into the work. We looked over possibility of a temporary road, and he is to make some further examination of this and I am to see him again and look the ground over with the plan which we prepared about a year ago, and which was not at hand at the time of this visit. I have visited the dam once or twice in the interval since my last report of September 30, but there is nothing special to record.

Visited Fernwood Lake Dam November 12, 1929, late in the afternoon. A rough stone wall composed mainly of one man stone has been laid up along the face next the water of the dam south of the old ice house. This wall has a batter by estimate of about 1 : 4 and is apparently laid on top of the old riprap or rough paving, and the top of the new wall is said to be 2 feet higher than the old dam. Material is being hauled from the pit at the site of the old house near the large ice house and the fill is wide enough to permit a truck to drive along the top of it. I doubt if the wall as laid would stand a great many years, but it without doubt affords some protection for the face of the fill next the water, and will apparently be sufficient to give stability to the added height of the dam which we have required. Mr. Abbott was not present at the time of my visit but I am told by Mr. Romans that he intends to loam and seed the top of the bank to prevent the dust from blowing on to the ice in the pond.

#### FERNWOOD LAKE DAM

I visited the dam about 3:00 P. M., December 20, 1929, and looked over work with Mr. Abbott. They have finished all the work they intend to do this season and have done substantially everything contemplated in the decree of the Commissioners. The walls are complete and the fill has been made behind the walls, but largely for their own protection they intend to cover these fills with loam and seed them in the spring so that they may avoid as far as possible the blowing of dirt onto the ice from the top of these dams. The construction of the spillway will insure that water will be kept at a lower level than might have resulted under the old conditions, and the added fill which has been placed on top of these dams is merely an added safeguard against overtopping same by waves, so that conditions have been very much improved here, even although the width of the dam on the top is not all that could be desired. I have suggested to Mr. Abbott that as they get opportunity, it would be well to increase the thickness of the dam by dumping material on the slope away from the water. The wall which they have built on the dam farthest to the south is made up of small stone and these rest on riprap or paving which goes off very steeply for the inside face of a dam, and I have told him that here, also, it would be a very good precaution to dump stone on the water side of the dam as opportunity affords, and I think that he will do these things in the near future. For the present, the structure seems safe and the requirements of the decree have been complied with.

0007C

December 23, 1929.

To the Commissioners of Essex County:

Gentlemen:

In the matter of building a spillway and raising the top of the embankment of the dam at Fernwood Lake in the city of Gloucester by the Cape Pond Ice Company, in accordance with your approval of plans and specifications issued under date of September 10, 1929, I would respectfully report that this work has been in progress up to within a few weeks and is now complete in so far as the requirements of your decree are concerned, although it is the intention of the owners to do some loaming and sodding in the spring.

The owners, of their own initiative, have laid a stone wall for the entire length of both of the dams on the westerly side of the pond in order to get a greater top width on the embankment, as the foundations of these walls are not carried below the surface which is partially rock fill and partially earth, apparently. The walls may not prove very permanent, but they afford a good protection against the wash of the waves for the present, and with some attention can apparently be made to serve their purpose indefinitely.

Respectfully submitted,

County Engineer.

E/A-2

D 9 —  
GLOUCESTER  
5-5-107-9

FERWOOD LAKE OUTLET

L.E. WILKINSON

7/7/71

2

NORTHWEST END OF FERWOOD LAKE. BEGIN ON ESSEX AVE.  
(ROUTE 133) AT FERWOOD LAKE AVE. TAKE FERWOOD LAKE AVE.  
SOUTH & WESTECLY  $\approx$  0.20 MI. TO SPILLWAY (SEE SKETCH)

DAMMER CITY OF GLOUCESTER

USE WATER SUPPLY

MATERIALS & TYPE EARTH & STONE PAVED ON THE WATER SIDE WITH FIELD  
STONES

HEIGHT OF DAM  $6.0 \pm$  FT.

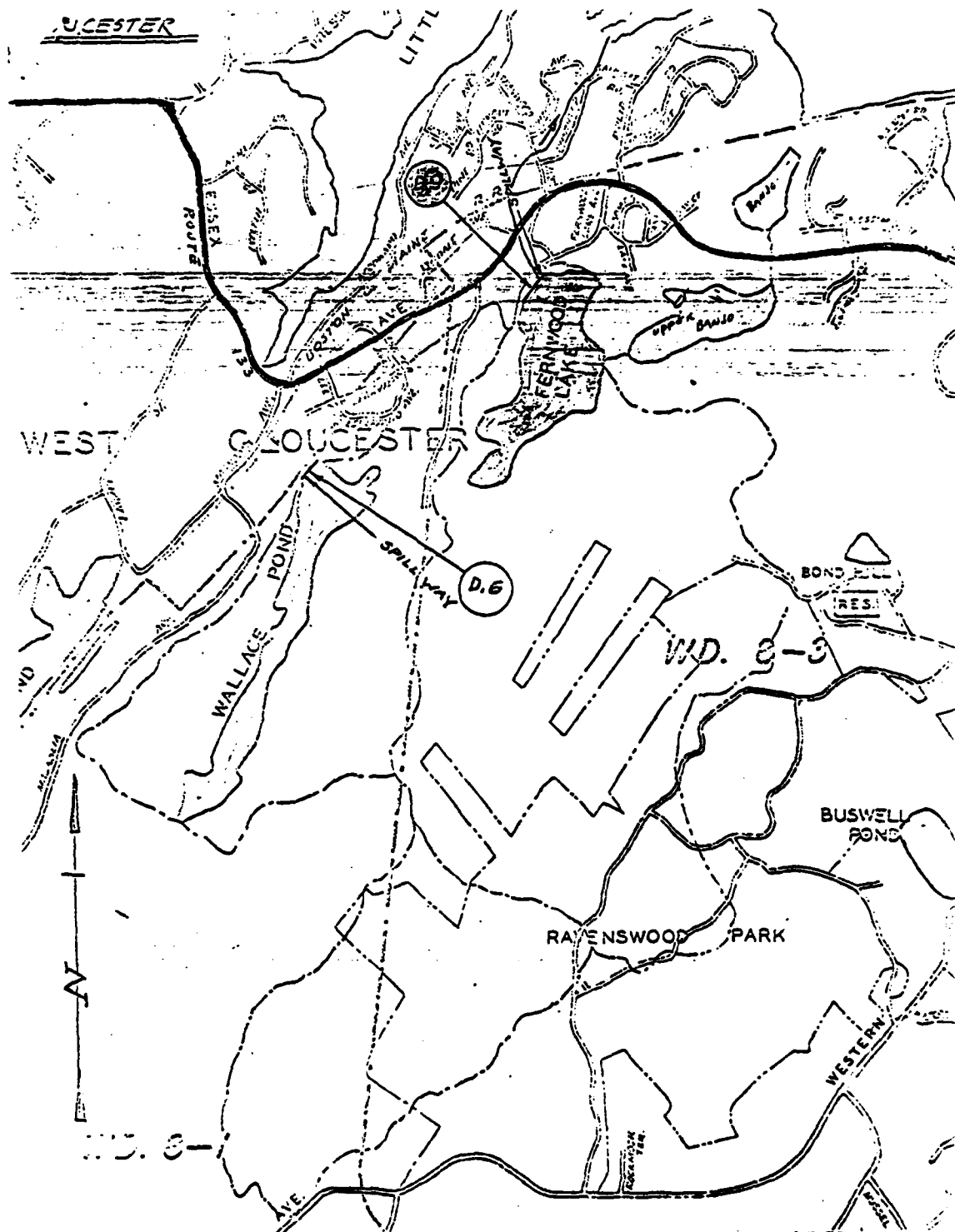
LENGTH 400.0  $\pm$  FT. TOP WIDTH 12.0 FT. POND AREA 20.0  $\pm$  ACRES

VOLUME OF WATER IMPOUNDED 0.50 SQ. MI.

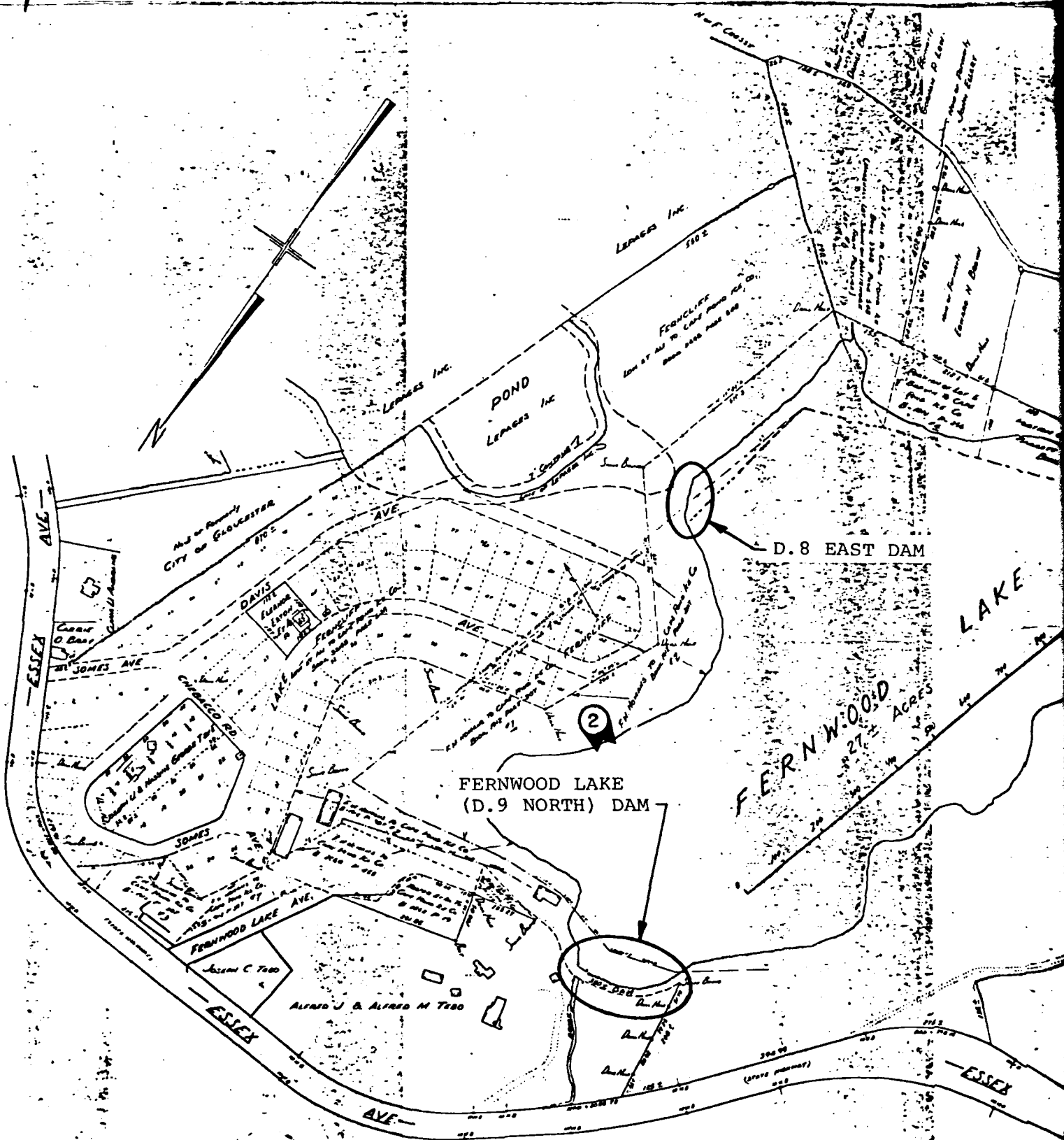
DESCRIPTION OF SPILLWAY  $13 \frac{1}{2}$ " OF FLASHBOARDS IN PLACE TO-DAY

WATER LEVEL  $2 \frac{1}{2}$ " BELOW TOP OF BOARDS - NO WATER IN SPILLWAY  
CONCRETE SPILLWAY & DAM ITSELF IN GOOD CONDITION.

RECOMMENDATIONS THREE OR FOUR LIVE TREES IN SLUICeway SHOULD  
BE CUT TO MAKE CLEAR CHANNEL







NOTE: THIS PLAN COMPILED FROM PLANS AND OTHER INFORMATION ON FILE IN THE CITY ENGINEERS OFFICE.



O. 108-5-C

D. 7 R. S. P.

COUNTY OF ESSEX, MASSACHUSETTS  
ENGINEERING DEPARTMENT

Inspection of Dams, Reservoirs, and Stand Pipes

O. 108-5C

SUB NUMBER  
D. 7 R. S. P.

Neg. No. 492

Inspector C. C. Barker Date April 24, 1912 Classification 7

City or Town Gloucester Location Westerly end of Fernwood Lake, South of Essex Ave.

Owner Cape Pond Ice Co. Use Ice pond

Include such details as curve, cut off walls, paving, bedding, class of masonry, kind of cement (port. or nat.) etc.

Material and Type Earth paved on the upstream side with large and small field stone

Elevations in feet: above (+) or below (-) full pond or reservoir level. (Cross out what does not apply.)

For Dam					
Bed of stream below	Bottom of pond	Bottom of spillway	Top of dam	Top of flash boards	
For Res. or S. P.					
Ground surface below	Bottom of res.	Level of over-flow pipe	Top of res.		

Length in ft. 40.0 Top width in ft. 8 Pond area 20.5 acres Area of watershed 1/2 sq. mi.

For Res. or S. P. Capacity covered open

Length of overflow or spillway Outlet pipes (size and notes)

Stand pipe, thickness at base diam. of steel head Pitch 1 in 12

Foundation and details of construction

Constructed by and date

Recent repairs and date

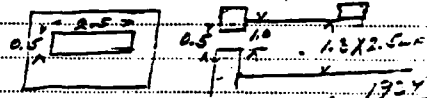
Evidence of leakage Land below is quite wet probably some leakage

Condition Fair S. P. when painted Paint

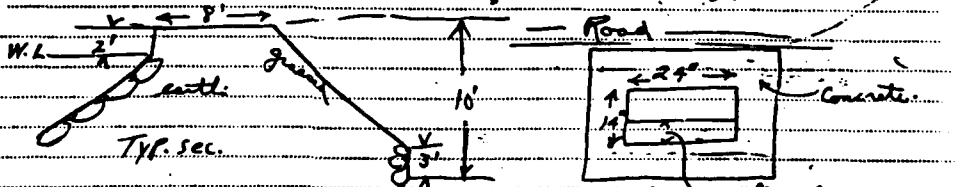
Topography of country below

Nature, extent, proximity, etc. of buildings, roads or other property in danger if failure should occur None

Plans and data secured or available



Use separate sheet for sketches if necessary. Notes, sketches, sections, etc. There is a concrete spillway west of dam that empties into Wallace Res. 24' wide 14' deep with 6" of flash boards.



No changes from Oct 16 1916. Q. & W.

\*Classify as to probable damage in case of failure. 3 slight. 2 moderate. 1 serious.

Gloucester, D. 7

1917, March 26. Watershed 0.5 sq. m. Max. Ht. 10.0 ft. Apparent condition, Fair.

1925, Oct. 29. R. R. Evans, Insp. There are three separate dams forming Fernwood Lake, all belonging to the Cape Pond Ice Co. The dam (#7) at the north end is an earth dam between rubble walls. It is in fairly good condition and is somewhat higher than that at the north east end.

1925 Report to Co. Comm. Same as above.

1928, Oct. 5. C. C. Barker, Insp. Dam on the westerly end of Fernwood Lake south of Essex Avenue, is owned by the Cape Pond Ice Company, and the pond is used for cutting ice. I gave a copy of the notice to E. Raymond Abbott, Supt., who went to the dam with me. Below the dam is a flat woody country and there would not be much, if any, damage in case of failure. In two places on the upper side the bank is somewhat washed out. These holes should be filled in and some stones put along the upper face to prevent wave action. The dam is well grassed over and there are quite a few bushes on the dam which should be cut. West of this dam at the outlet to the pond there is a small spillway which is in good condition. The Cape Pond Ice Company try to keep this pond at the same level and let the waste water go into Wallace Pond to be used by the city. Mr. Abbott thinks the city should clean out the brook for their own benefit and build a larger spillway so they would be able to get more water. When the pond rises faster than the small spillway will take care of it, the eight inch draw off pipe at the other end of the pond is opened and the water goes into the Russia Cement Company's pond. Mr. Abbott says that the bushes along the dam are cut every year and he intends to put some stones along the upper slope and fix any slopes that are washed out, and he will co-operate in any way to keep the dam in good condition.

1928, Nov. 30. R. R. Evans, Insp. Fernwood Lake: I inspected various dams except that at north end, which is rather unimportant. Too much depends on regulating the level of this pond by means of the draw off pipes which are small. There should be a spillway. The spillway at the end next Wallace Pond could easily be made sufficient, which would add water shed of this pond to that of Wallace Pond. Levels and further investigations are needed to determine just what would become of the overflow in case of failure of the dam along Essex Avenue side nearest Wallace Pond, and conference with the owner seems desirable. At the present level of the pond there is not enough height of embankment above the water in many places

1928 Report to Co. Comm. Fernwood Lake Dams. There are three dams at Fernwood Lake at the east, north and west sides and a very low dam at the south end with a small culvert leading through it. All are owned by the Cape Pond Ice Company. The dam at the east end is of little importance. There is another pond below it and no failure seems likely which would cause serious damage. The dam at the northerly end, is the highest, about sixteen feet, and if it failed would cause damage to the highway, to the railroad, and probably to the garage on the north side of the highway, while the dam at the west side which is about eight feet high at maximum, is bordered by flat country between it and the highway and practically all of the flood in case of a break here would apparently find its way to Wallace Pond and might cause trouble there. There is no spillway for the discharge of flood water from the lake, entire

## Gloucester, D. 7

reliance being placed on opening the gates and drawing down the pond level so that it will be safe in times of heavy rains, and none of the dams is as high above water level as it stood at the time of my visit on November 30 as they should be. The small culvert at the south end is of no value as a spillway. In view of the character of these dams, which are all of earth, there should be a spillway of adequate dimensions provided at some point, and the dams should be raised or the pond level lowered. This spillway might be located at the south end, allowing the overflow water to discharge into Wallace Pond if agreeable to the City of Gloucester, in which case the addition of the Fernwood Lake watershed to the water shed of that pond would have to be considered or, it might discharge at some other point. Under present conditions, it is not apparent that wide spread damage would be done by a failure at these dams except possibly at Wallace Pond, but there is a considerable amount of building going on in this locality and a spillway should be provided at once.

1930, Sept. 16. C. C. Barker, Insp. Dam on the westerly end of Fernwood Lake south of Essex Avenue, is owned by the Cape Pond Ice Company. The pond is used for cutting ice. I gave a copy of the notice to E. Raymond Abbott, Supt. No one inspected the dam with me. The country below the dam is flat and woody. There would be no damage in case of failure. Since the last inspection, this dam has been raised about 2 feet and put in good condition. A vertical dry wall about 3.5 feet high has been built along the inner face of the dam.

1930 Report to Co. Comm. Three dams on Fernwood Lake south of Essex Avenue at the westerly, easterly and northerly sides of the pond, are the property of the Cape Pond Ice Company. The state highway is below this pond and there are some buildings which might be damaged in case of failure, especially of the northerly dam. Both the westerly and northerly dams have been raised and a spillway built since the last inspection, and these were described in my report of last year. The structures are now apparently safe and in good condition.

1932, Aug. 2. C. C. Barker, Insp. I saw Mr. E. Raymond Abbott, Supt. The dam is in good condition. There has been no change.

1932 Report to Co. Comm. Safe and in reasonably good condition.

1934, Sept. 28. C. C. Barker, Insp. I gave a copy of the notice to E. Raymond Abbott, Supt. No one inspected the dams with me. This dam is in good condition, except there are a few bushes that should be cut, and there has been no change.

1934 Report to Co. Comm. Safe and in reasonably good condition.

1936 August 10, C.C.Barker, Insp. I saw E. Raymond Abbott, Supt. This dam is in good condition except for a bushes which are cut every year. There has been no change.

1936 Report to Co. Comm. Safe and in reasonably good condition.

Gloucester D. 7

1938 October 26, C.C.Barker, Insp. I gave a copy of the notice to E. Raymond Abbott, Supt. This dam is in good condition and there has been no change. However, at the westerly end of the pond the small outlet to the culvert has been closed and if the water level raised 6 inches it would overflow the wood road at this culvert. It would cause no damage.

1938 Report to Co. Comm. Safe and in reasonably good condition.

1940 Oct. 4, C.C.Barker, Insp. I talked with Mr. Abbott, Supt. over the telephone. This dam is in good condition and there has not been any change.

1940 Report to Co. Comm. Safe and in reasonably good condition.

1942 Aug. 3, C.C.Barker, Insp. I talked over the phone with E. Raymond Abbott, Supt., and left a copy of the notice at the office for him. This dam is in good condition. The pond is full and there has not been any change.

1942 Report to Co. Comm. Safe and in reasonably good condition.

1944 July 26, S.W.Woodbury, Insp. I gave a copy of the notice to Mr. Abbott, but visited this dike alone. Dike is covered with high bushes. There is a wood road just below this dike. Conditions here apparently are about the same.

1944 Report to Co. Comm. Safe and in reasonably good condition.

1946 Sept. 24, S.W.Woodbury, Insp. There is a new owner. See D9. I gave a copy of the notice to Mr. Tebo and went to dam alone. Condition of the dam is the same.

1946 Report to Co. Comm. Safe and in reasonably good condition.

1948 Sept. 30, S. W. Woodbury, Insp. Gave a copy of the notice to Mr. Sundbeck for Mr. Tebo and went to dam alone. Condition of the dam is the same.

1948 Report to Co. Comm. Safe and in reasonably good condition.

1950 Sept. 27, S.W.Woodbury, Insp. Gave a copy of the notice to Mr. Tebo and went to dam alone. Water level today: Same as D 9. Condition of the dam is the same. Culvert nearly blocked. Note: Another dike here should be numbered?

1950 Report to Co. Comm. Safe and in reasonably good condition.

1952 Sept. 25, E.H.Page, Insp. City of Gloucester New owner, (Water Works) Gave a copy of the notice to Mr. Hull at Water Dept. Office and went to dam alone. Water level today same as D 9. Culvert nearly blocked.

1952 Report to Co. Comm. Safe and in reasonably good condition.

Gloucester D. 7

D. 7 Sh. 4

1954, May 28, E.H. Page, Insp. (Atten. Insp. - Take middle wood road at D.P.W. Maintenance Depot drive.



Culvert almost completely blocked. A dike has been built across this end of the lake about 200' or 300' from the end. It is constructed out of boulders with a gravel top. It is about 11' or 12' wide. Wave action is washing away gravel on the lake side. Water is about 12" below top now. Water level is the same on both sides, but I do not see any culvert. At the old dike, the culvert is blocked tight. Some seepage on the southerly side of culvert.

1954 Report to Co. Comm. At Fernwood Lake, westerly end, south of Essex Street, a new dike has been built across this end of the lake about two hundred or three hundred feet from the end. It is constructed of boulders with a gravel top and is eleven or twelve feet wide. Wave action is washing away gravel on the lake side as the water is only about twelve inches from the top. Water level is the same on both sides of the dike, although there is no culvert visible. At the old dike, the culvert is blocked tight. Some seepage on the southerly side of the culvert.

1956, Sept. 13, E.H. Page, Insp. Elev. of Water: Water about 3' below new dike across the end of the pond. Leaks: Some seepage.

1956 Report to Co. Comm. At Fernwood Lake, there is a great deal of debris on each side of the flashboards. This should be removed.

1958, Jan. 29, E.H. Page & A.A., Insp. Elev. of water: 0.3 over flashboards. Much debris holding back water against flashboards.

1958, Dec. 30, E.H. Page & R.M. Jackson, Insp. Elev. of water: Water about 1' + below new dike. Heavy erosion on new dike. Some rubble has fallen into pond from old dike.

1958 Report to Co. Comm. At Fernwood Lake, at the westerly end, there is heavy erosion on the new dike and some of the rubble wall of the old dike has fallen in the pond. At the northerly end there is a great deal of debris up against the flashboards.

1961, Jan. 12, E.H. Page & P.D. Killam, Insp. Condition: Same.

1960 Report to Co. Comm. At Fernwood Lake at the westerly end, there is heavy erosion on the new dike. This is not too important as water is the same height on either side of dike. Some of the rubble wall on the old dike has fallen into the pond.

1962 Report to Co. Comm. At Fernwood Lake at westerly end, there is erosion of the new dike. This is not too important as water is same height on either side of the dike. Some rubble from wall on the old dike has fallen into the pond.

Gloucester D. 7

D. 7 Sh. 5

1964 Dec. 29, P.D.K. & K.M.J., Insps. Brush and large trees should be controlled.

1964 Report to Co. Comm. Safe and in reasonably good condition.

1966 April 17, 1967. Brush and large trees should be controlled.

1966 Report to Co. Comm. Brush and trees on earth embankment should be cut.

1968 April 38, 1969. P.D.Killam and J. Fitzgerald. Brush and tree: cutting has been carried on here

D. 9A —  
GLOUCESTER  
5-5-107-10

L. E. WILKINSON

7/7/71

2

SOUTHWESTERLY SIDE OF FERNWOOD LAKE. BEGIN ON ESSEX AVE. (ROUTE 135) AT STANWOOD AVE. - TAKE ESSEX AVE. WESTERLY 0.25 MI. TO A WOODS ROAD ON SOUTH SIDE OF ESSEX AVE. TAKE THIS ACCESS ROAD SOUTHERLY 0.20 MI. TO DAM.

OWNER: CITY OF GLOUCESTER

USE: WATER SUPPLY

MATERIALS: THE EARTH AND STONE PAVED ON LAKE SIDE.

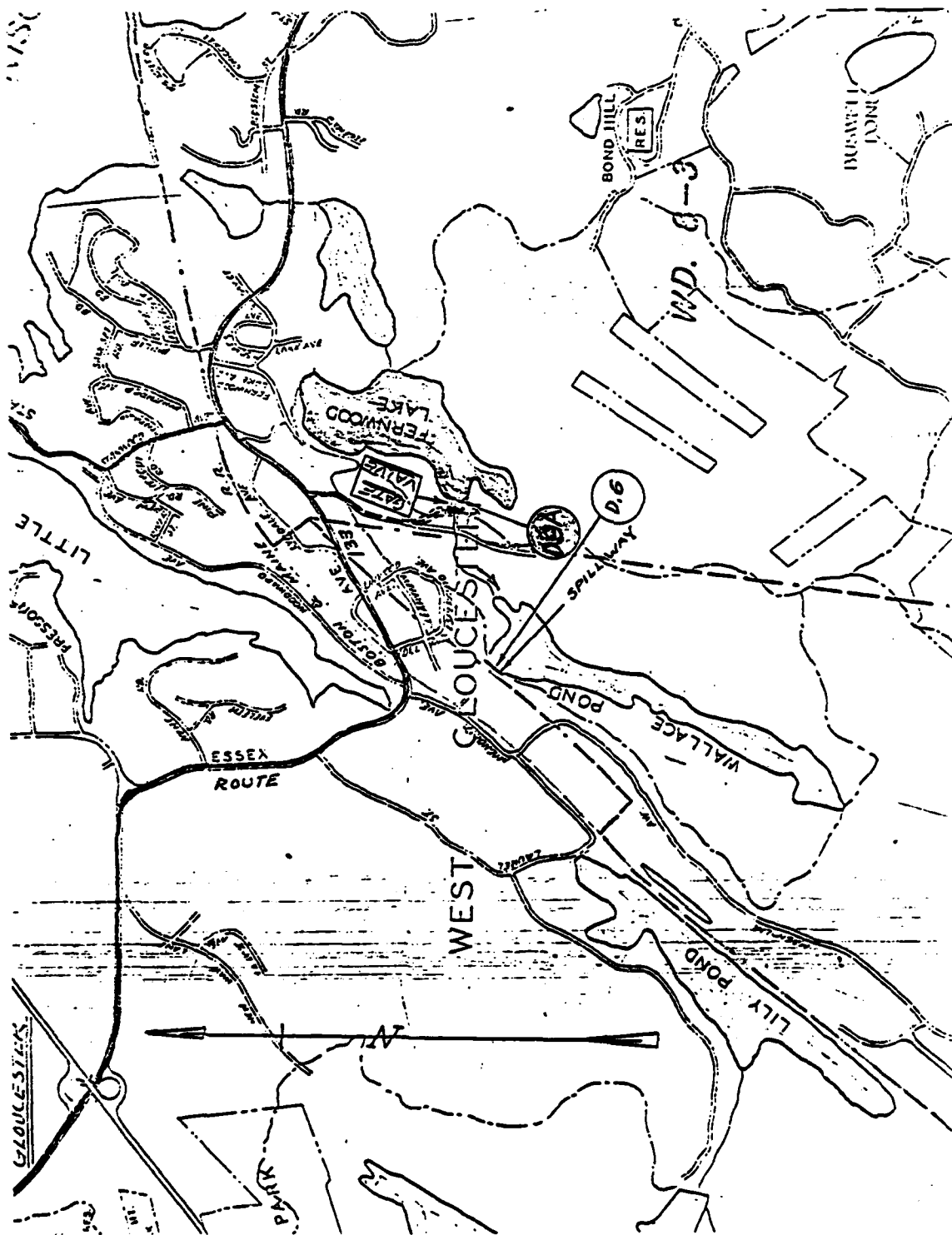
HEIGHT OF DAM: 6.0 ± FT.

LENGTH: 330.0 ± FT. TOP WIDTH: 10.0 ± FT. POND AREA: 20.0 ± ACRES

VOLUME OF WATER IMPOUNDED: 0.50

DESCRIPTION OF SPILLWAY: NONE. THIS DAM FUNCTIONS AS A SIMPLE DIKE EXCEPT THERE IS A 14" STEEL DRAW OFF PIPE THROUGH IT WITH GATE VALVE LOCATED JUST BELOW FOOT OF DOWNSTREAM FACE OF DAM. THIS PIPE OUTLETS INTO BROOK CHANNEL FLOWING INTO WALLACE POND.

RECOMMENDATIONS: EVERYTHING AT THIS DAM IN GOOD CONDITION. WATER LEVEL 2.0 FT. BELOW TOP TO-DAY.



0 101-5-C  
D P R S P

COUNTY OF ESSEX, MASSACHUSETTS  
ENGINEERING DEPARTMENT

Inspection of Dams, Reservoirs, and Stand Pipes

0 1085C

SUB NUMBER  
D. P. R. S. P.  
Reg. No. 493

Inspector P. C. Barker Date April 24, 1912 \*Classification 7  
City or Town Gloucester Location Northeasterly end of Fernwood Lake  
East of West Gloucester Station  
Owner Lake Pond Ice Co. & E. Raymond Use Ice Pond  
Includes such details as core, cut off walls, paving, bedding, class of masonry, kind of cement, (nat. or port.) etc.  
Material and Type Earth and stone (4.5 ft. high)

Elevations in feet: above (+) or below (-) full pond or reservoir level. (Cross out what does not apply.)

For Dam  
Bed of stream below Bottom of pond Bottom of spillway Top of dam Top of flash boards  
For Res. or S. P.  
Ground surface below Bottom of res Level of over flow pipe Top of res  
For dam  
Length in ft. 100 Top width in ft. 14 Pond area 20± acres Area of watershed 6± sq. mi.  
For Res. or S. P.  
Inside dimensions Capacity covered open

Length of overflow or spillway Outlet pipes (size and nature)

Stand pipe, thickness of base, diam. of rivet head, Pitch from

Foundation and details of construction

Constructed by and date

Recent repairs and date

Evidence of leakage land below is wet none

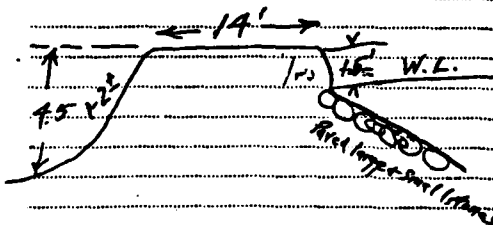
Condition Good S. P. when painted from

Topography of country below (Woody)

Nature, extent, proximity, etc. of buildings, roads or other property in danger if failure should occur None

Plans and data secured or available

Use separate sheet for sketches if necessary.  
Notes, sketches, sections, etc. There is another pond 500± ft. below this dam. There is an 8" outlet or draw-off pipe no overflow.



No danger 9th Oct. 16, 1912 A.C.W.

\*Classify as to probable damage in case of failure. 3 slight. 2 moderate. 1 serious.

Gloucester D. 8

1917, March 26. Watershed 0.5 sq. m. Max. Ht. 4.5 ft. Apparent condition, Good.

1925, Oct. 29. R. R. Evans, Insp. There are three separate dams forming Fernwood Lake, all belonging to the Cape Pond Ice Co. At the north east end the earth dam (#8) or dike is low and narrow, about four feet over the swamp below it, having very little height above full pond level. The pipe outlets are small and water from this point would find its way into the Russia Cement Company's pond on the south side of Essex Ave., but it is not apparent that any wash-out could occur which would release a flood wave of any magnitude.

1925 Report to Co. Comm. Same as above.

1928, Oct. 5. C. C. Barker, Insp. Dam on the easterly end of Fernwood Lake, is owned by the Cape Pond Ice Company, and the pond is used for cutting ice. I gave a copy of the notice to E. Raymond Abbott, Supt., who went to the dam with me. There is another pond just below this dam and there would be no damage in case of failure. The dam is in good condition and there have been no changes since the last inspection. There are some bushes on this dam which are cut every fall.

1928, Nov. 30. R. R. Evans, Insp. See D. 7

1928 Report to Co. Comm. See D. 7 - 1928 Report

1930, Sept. 16. C. C. Barker, Insp. Dam on the easterly end of Fernwood Lake, is owned by the Cape Pond Ice Company. This pond is used for cutting ice. I gave a copy of the notice to E. Raymond Abbott, Supt. No one inspected the dam with me. There is another pond just below this dam and in case of failure, there would be no damage. The conditions are the same and there have been no changes since the last inspection.

1930 Report to Co. Comm. See D. 7 - 1930 Report.

1932, Aug. 2. C. C. Barker, Insp. The dam is in good condition and there has been no change.

1932 Report to Co. Comm. Little importance.

1934, Sept. 28. C. C. Barker, Insp. The condition is the same and there has been no change.

1934 Report to Co. Comm. Structure is of little importance.

1936 August 10, C.C.Barker, Insp. This dam is in good condition, there has been no change.

1936 Report to Co. Comm. Structure is of little importance.

1938 October 26, C.C.Barker, Insp. This dam is in good condition and there has been no change.

1938 Report to Co. Comm. Structure is of little importance.

Gloucester D. 8

1940 Oct. 4, C.C.Barker, Insp. This dam is in good condition and there has not been any change.

1940 Report to Co. Comm. Structure is of little importance.

1942 Aug. 3, C.C.Barker, Insp. This dam is in good condition, and there has not been any change.

1942 Report to Co. Comm. Structure is of little importance.

1944 Nov. 13, S.W.Woodbury, Insp. I gave a copy of the notice to Mr. Abbott. I visited the dam alone. A new pipe has been placed around the shut-off valve. The pond is allowed to rise until it is 1 inch below the lip of the spillway at D 9 then valve at D 8 is opened and water is allowed to run to Russia Cement Company plant.

1944 Report to Co. Comm. Structure is of little importance.

1946 Sept. 24, S.W.Woodbury, Insp. New owner, see D 9. I gave a copy of the notice to Mr. Tebo and went to the dam alone. Condition is the same.

1946 Report to Co. Comm. Structure is of little importance

1948 Sept. 30, S. W. Woodbury, Insp. Gave a copy of the notice to Mr. Sundback for Mr. Tebo and went to dam alone. Water level today: Gate is open. Water is running through. 8" pipe about 1/4 full. Condition of the dam is the same.

1948 Report to Co. Comm. Structure is of little importance.

1950 Sept. 27, S.W.Woodbury, Insp. Gave a copy of the notice to Mr. Tebo and went to dam alone. Water level today: Same as D9 (Gate has been kept open to give water to Russia Cement Co. Condition of the dam is the same.

1950 Report to Co. Comm. Structure is of little importance.

1952 Sept. 24, E.H.Page, Insp. City of Gloucester (Water Works) new owner) Gave a copy of the notice to Mr. Hull at Water Dept. and went to dam alone. Water level today: Same as D 9. Gate closed today. Condition is the same.

1952 Report to Co. Comm. Structure is of little importance.

1954, May 28, E.H.Page, Insp. Seepage at toe. Gate is closed.

1954 Report to Co. Comm. Structure is of little importance.

1956 Sept. 13, E.H.Page, Insp. Condition: Same.

1956 report to Co. Comm. Structure is of little importance.

Gloucester D. 8

D. 8 Sh. 3

1958, Dec. 30, E.H. Page & K.M. Jackson, Insp. Condition: same.  
Some seepage around pipe.

1958 Report to Co. Comm. Structure is of little importance.

1960 Report to Co. Comm. Structure is of little importance.

1962 Dec. 17, K.M. Jackson, Insp. Owner: City of Gloucester Water  
Works. Condition of dam: Same as 1960 report.

1962 Report to Co. Comm. Structure is of little importance.

1964 Dec. 29, P.D.K. & K.M.J., Insp. Conditions the same.

1964 Report to Co. Comm. Structure is of little importance.

1966 April 17, 1967. P.D.K. & K.M.J., Insp. Conditions the same.

1966 Report to Co. Comm. Structure is of little importance.

# APPENDIX C - PHOTOGRAPHS

Page

## LOCATION PLAN

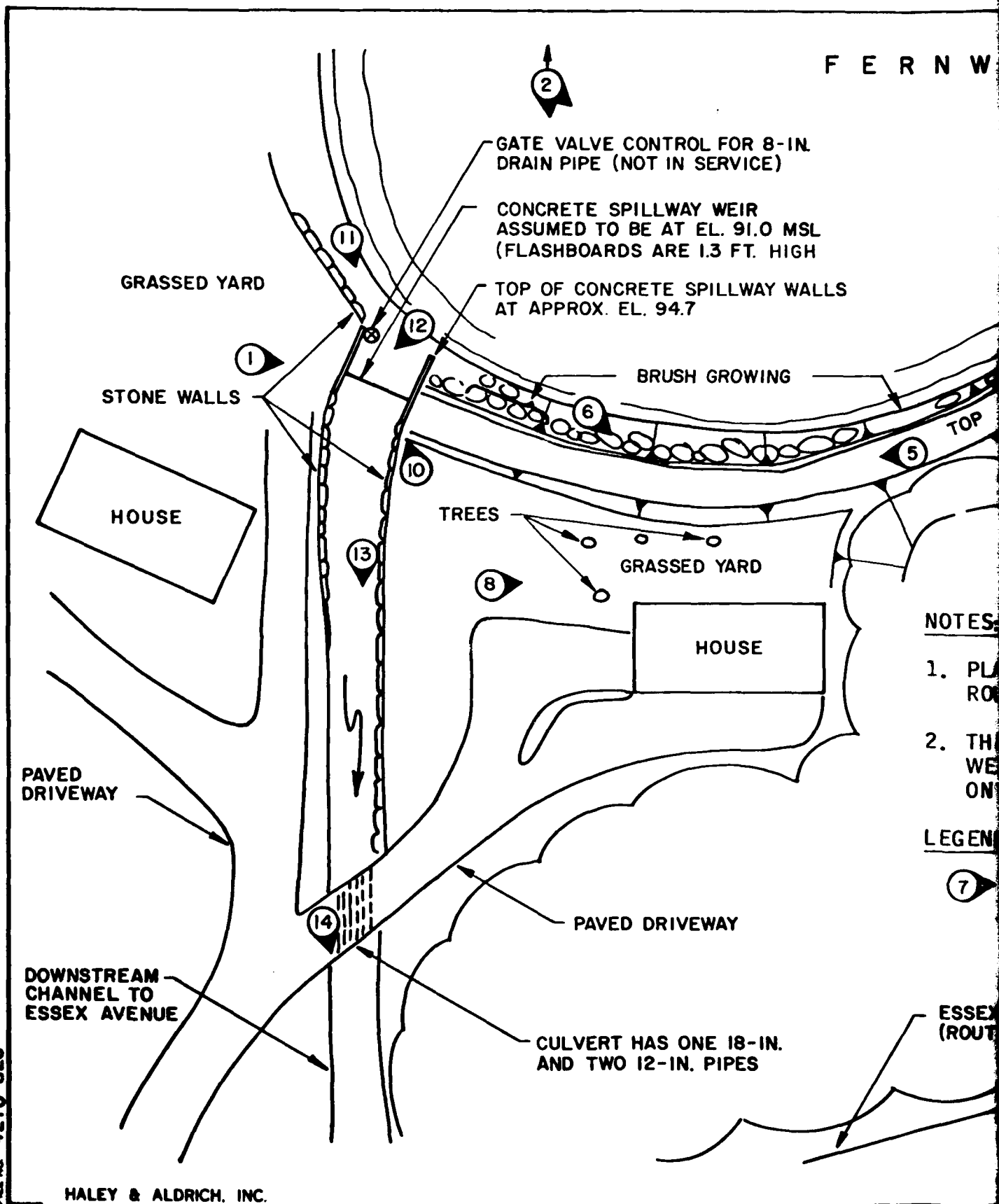
Site Plan Sketch

C-1

## PHOTOGRAPHS

<u>No.</u>	<u>Title</u>	<u>Roll</u>	<u>Frame</u>	<u>Page</u>
1.	Overview of Fernwood Lake Dam from right abutment	10	5	vi
2.	Overview of upstream face of Fernwood Lake Dam	10	1,2	C-2
3.	Upstream stone masonry wall near left abutment	C29	34A	C-3
4.	Top of embankment, capstone on masonry wall and upstream slope protection near left abutment	8	11	C-3
5.	Top of embankment near home left of spillway	C29	33A	C-4
6.	Upstream slope of embankment near home left of spillway	8	22	C-4
7.	Top of embankment and wooded downstream slope	8	12	C-5
8.	Downstream side of embankment and grassed yard left of spillway	C29	31A	C-5
9.	Right abutment of dam and upstream side near spillway	10	6	C-6
10.	Approach channel, flashboard supports and stone paved apron of spillway	C29	26A	C-6
11.	Left concrete spillway wall at right abutment of embankment	8	17	C-7
12.	Right concrete spillway wall, stone masonry wall on right side of downstream channel and inoperative gate valve control	C29	24A	C-7
13.	Downstream channel from spillway to pipe culvert	C29	28A	C-8
14.	Downstream channel from pipe culvert to Essex Avenue	C29	30A	C-8
15.	Upstream face of West Dam along southwest shoreline of Fernwood Lake	C29	35A	C-9
16.	South Dike cuts off the southern tip of Fernwood Lake	C29	36A	C-9

FERNW



NOTES:

1. PL
2. TH WE ON

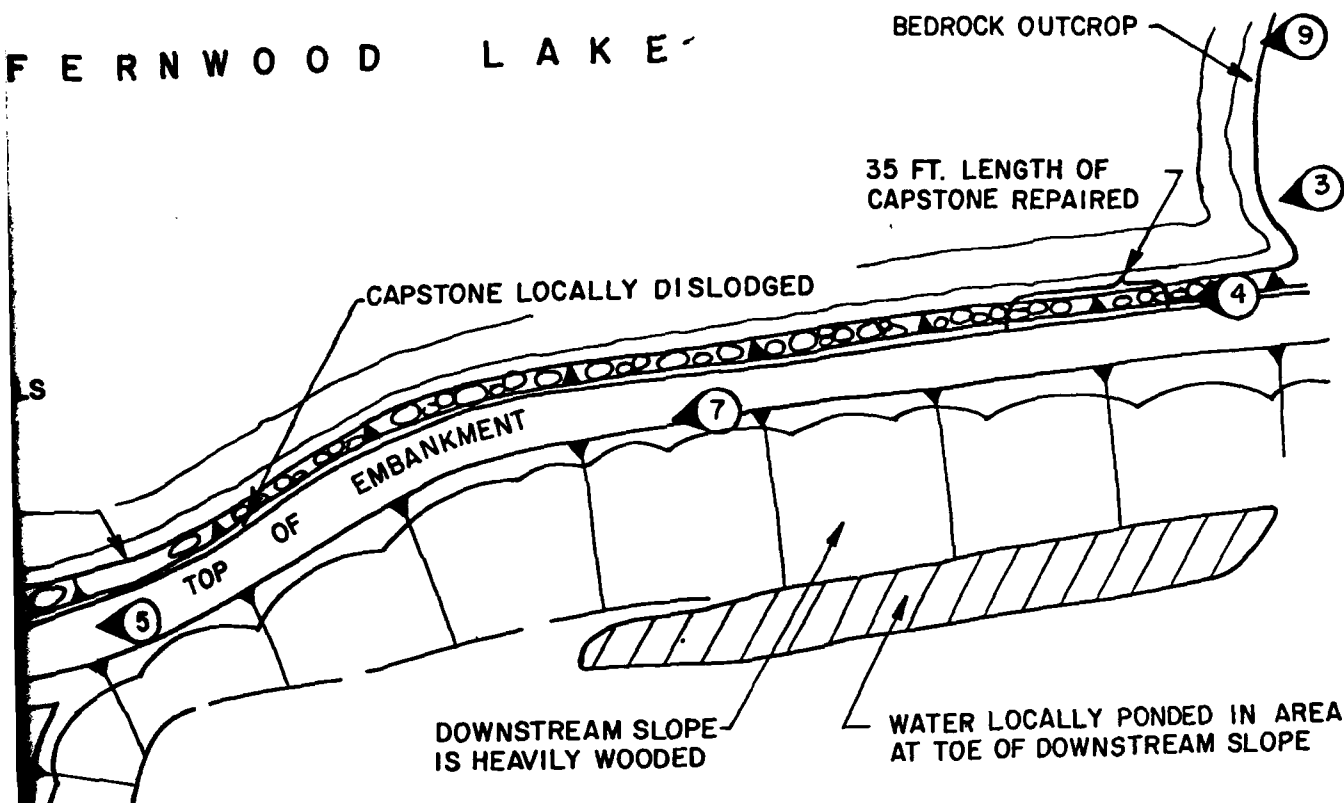
LEGEND

7

FILE NO. 4270 B28

HALEY & ALDRICH, INC.  
CAMBRIDGE, MASSACHUSETTS

# FERNWOOD LAKE



## NOTES:

1. PLAN DEVELOPED FROM FIELD OBSERVATIONS AND ROUGH MEASUREMENTS MADE ON 6 DECEMBER 1978.
2. THE LOCATIONS WHERE PHOTOS NO. 2, 15 AND 16 WERE TAKEN FROM ARE SHOWN ON THE DRAWING ON PAGE B-24.

## LEGEND

- ⑦ PHOTO NO. AND DIRECTION OF VIEW.

ESSEX AVENUE  
(ROUTE 133)

Fernwood Lake Dam  
Gloucester, MA  
SITE PLAN SKETCH

Approx. Scale: 1"=40'

March 1979

C-1



2. Overview of upstream face of Fernwood Lake Dam



3. Upstream stone masonry wall near left abutment



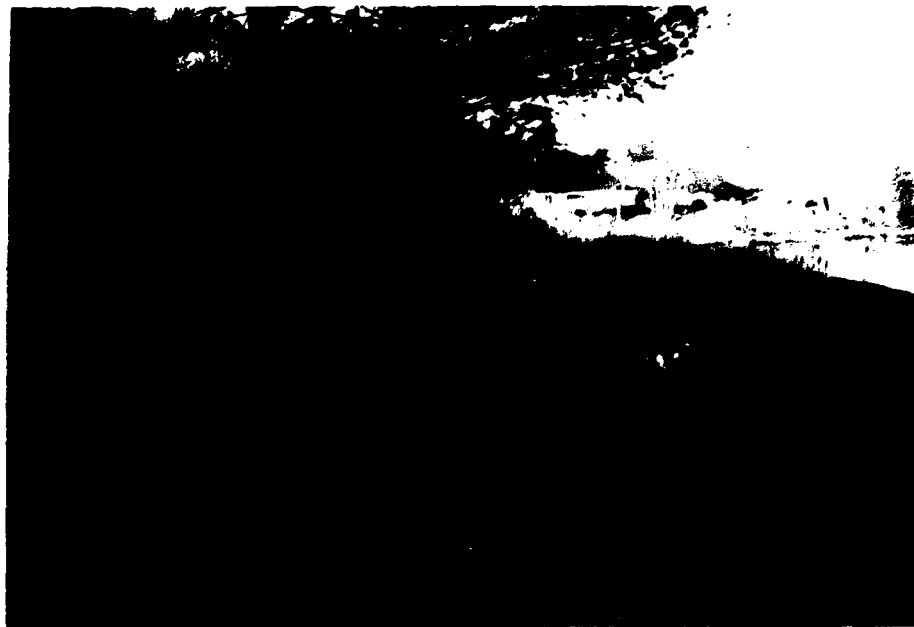
4. Top of embankment, capstone on masonry wall and upstream slope protection near left abutment



5. Top of embankment near home left of  
spillway



6. Upstream slope of embankment near home  
left of spillway



7. Top of embankment and wooded downstream slope



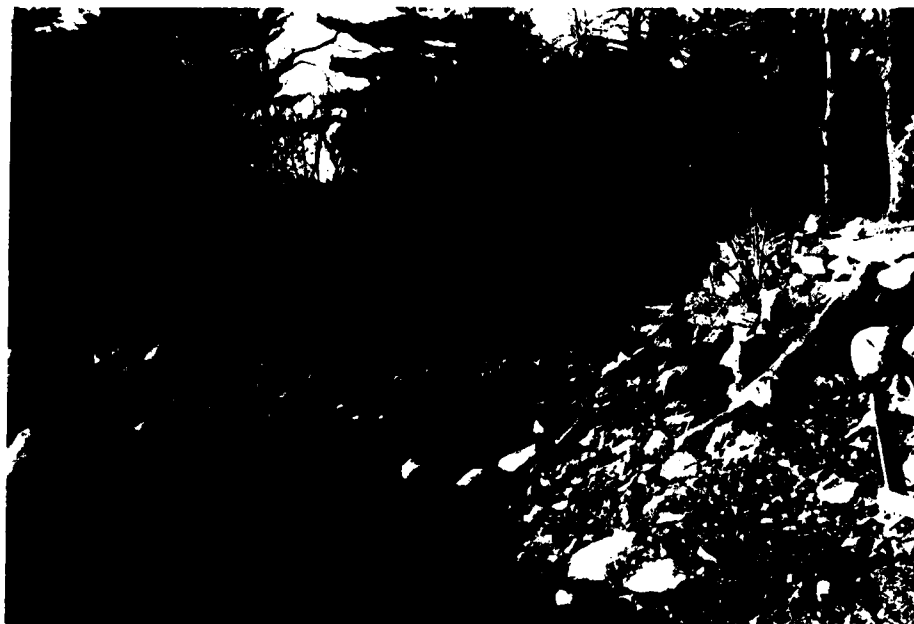
8. Downstream side of embankment and grassed  
yard left of spillway



9. Right abutment of dam and upstream side near spillway



10. Approach channel, flashboard supports and stone paved apron of spillway



11. Left concrete spillway wall at right abutment of embankment



12. Right concrete spillway wall, stone masonry wall on right side of downstream channel and inoperative gate valve control



13. Downstream channel from spillway to pipe culvert



14. Downstream channel from pipe culvert to Essex Avenue



15. Upstream face of West Dam along southwest shoreline of Fernwood Lake



16. South Dike cuts off the southern tip of Fernwood Lake

## APPENDIX D - HYDROLOGIC AND HYDRAULIC COMPUTATIONS

	<u>Page</u>
<u>Computations</u>	
Drainage & Failure Flood Impact Area Map	D-1
Size Classification, Hazard Potential and Test Flood	D-2
Surcharge-Storage Routing	D-3
Stage-Discharge Curve (1.3 ft. flashboards)	D-5
Area-Volume Curve	D-6
Stage-Discharge Curve (No flashboards)	D-7
Downstream Channel and Tailwater	D-9
Dam Failure Analysis	D-13



**CAMP DRESSER & McKEE Inc.**  
 Consulting Engineers  
 Boston, Mass.



**FERNWOOD LAKE DAM**  
**DRAINAGE & FLOOD**  
**IMPACT AREA**  
**SCALE: 1:24,000 D-1**

CLIENT H & A  
 PROJECT SDE Dam Inspection  
 DETAIL Fernwood Lake Dam

JOB NO 561-9-Rt-5DATE CHECKED 3/20/79CHECKED BY JEDPAGE 1DATE 3/2/79COMPUTED BY HLG

### Size Classification

Height:  $95.5 - 76.5 = 19\text{-ft} < 40\text{-ft}$

(At a section about 300-ft west  
of the spillway)

Storage: 380 acre-ft  $< 1,000\text{ ac-ft}$   
 (@ elev 95.5)

} SMALL

### Hazard Potential Classification

The downstream channel capacity is relatively very small; the dam is too long for a confined channel flow in the event of a failure. The following properties are expected to be subject to flooding from a failure: One house 50 to 100-ft west of the spillway, at the toe of the dam; the paved access road to two houses and to the spillway; four single family homes and a garage-repair shop on the northern side of the Essex avenue, and possibly ~~the~~ seven single family homes beyond the B&M railroad towards north. The hazard potential is considered "HIGH" because of high potential for loss of lives and extensive property damages.

### Test Flood Development

Size: Small  
 Hazard: High }  $\rightarrow Q_T = \frac{1}{2} \text{ PMF to PMF}$   
 use  $\frac{1}{2} \text{ PMF}$

Watershed: midway between flat-coasted and rolling  
 Drainage Area: 0.52 sqmi  
 Peak Flow Rate = 1,825 cfs/sqmi

PMF inflow = 950 cfs.

Test Flood inflow: 475 cfs.

CLIENT H & A JOB NO 561-9-R4-5 PAGE 2  
 PROJECT COE Dam Inspection DATE CHECKED 3/20/79 DATE 3/2/79  
 DETAIL Fernwood Lake Dam CHECKED BY JED COMPUTED BY AUG

### Surcharge - Storage Routing

$$Q_p = 475 \text{ cfs } (1/2 \text{ PMF} \rightarrow \text{Max. Runoff} = 9.5 \text{ -in})$$

Condition 1: The existing 1.3 ft high flashboards stay: (El. 92.3)

WSE @ the pond:  $\approx 94.0$  (See stage-discharge curve, page D-5)

Volume = 325 ac-ft @ El. 94.0 (See Area-Volume curve, page D-6)

Normal Pond Volume: 265 ac-ft @ El. 92.3 (assumed)

Surcharge = 60 ac-ft

$$\text{STOR 1} = \frac{60 \times 12}{333} = 2.16 \text{ -in}$$

$$Q_p = 475(1 - \frac{2.16}{9.5}) = 367 \text{ cfs} \rightarrow \text{WSE} = 93.9$$

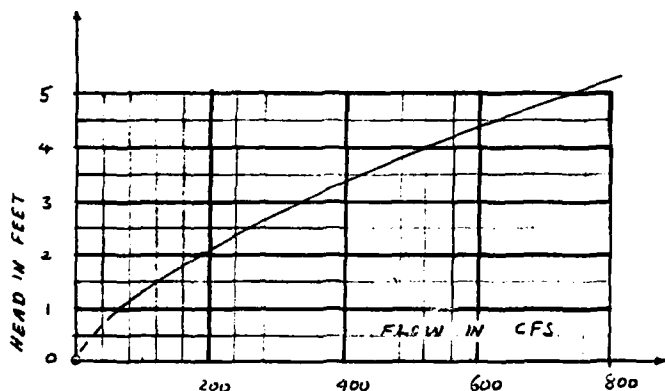
Vol. = 325 ac-ft

$$\text{STOR 2} = \frac{(325 - 265) \times 12}{333} = 2.16 \text{ -in}$$

$$\text{STOR}_{AV} = 2.16 \text{ -in}$$

WSE = 93.9 @ Vol. = 325 ac-ft  $\rightarrow$  Test Flood Outflow = 370 cfs.

About 150 cfs of the total would flow over the spillway, which would require a head of 1.7-ft as can be seen in the curve below;  $93.9 - 92.3 = 1.6 \text{ -ft} \approx 1.7 \text{ ft}$ . The remaining 220 cfs would flow over the East and South dams.



HEAD - CAPACITY CURVE - SPILLWAY

(With 1.2-ft high Flashboards)

CLIENT HWA JOB NO. 561-9-41-5 PAGE 3  
 PROJECT CDF Dam Inspection DATE CHECKED 3/20/79 DATE 3/2/79  
 DETAIL Fernwood Lake Dam CHECKED BY JED COMPUTED BY MIC

Condition 2 . No flashboards at the spillway crest (E1.91.0)

$Q_p = 475$  cfs  $\rightarrow$  WSE = 94.0 (See stage-discharge, page D-7)

Volume : 325 ac-ft.

$$STOR 1 = \frac{(325-225)12}{3.33} = 3.60'$$

$Q_{p_2} = 475(1 - \frac{3.60}{9.5}) = 295$  cfs.  $\rightarrow$  WSE = 93.8  
 Volume = 320 ac-ft.

$$STOR 2 = \frac{(320-225)12}{3.33} = 3.42'$$

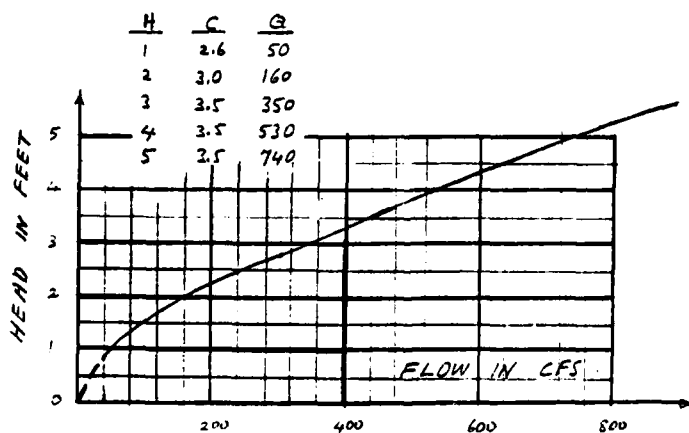
$STOR_{AVE} = 3.51$   $Q_p = 475(1 - \frac{3.51}{9.5}) = 300$  cfs.

WSE = 93.8 Vol. = 320 a.k.

Test Flood Outflow: 300 cfs @ WSE 93.8

The spillway head-capacity curve for this condition would be somewhat different because of the crest shape; 160 cfs would flow over the spillway and the remaining 140 cfs over the east and south drains - The required head at the spillway: 1.8 ~ 2.0 feet.

$$Q = CLH^{3/2}$$



HEAD-CAPACITY CURVE  
 SPILLWAY  
 (No Flashboards)

CAMP DRESSER & MOORE INC.

CLIENT HWA  
 PROJECT CDF Dam Inspection  
 DETAIL Fernwood Lake Dam

JOB NO 561-9-14-5  
 DATE CHECKED 3/22/79  
 CHECKED BY VED

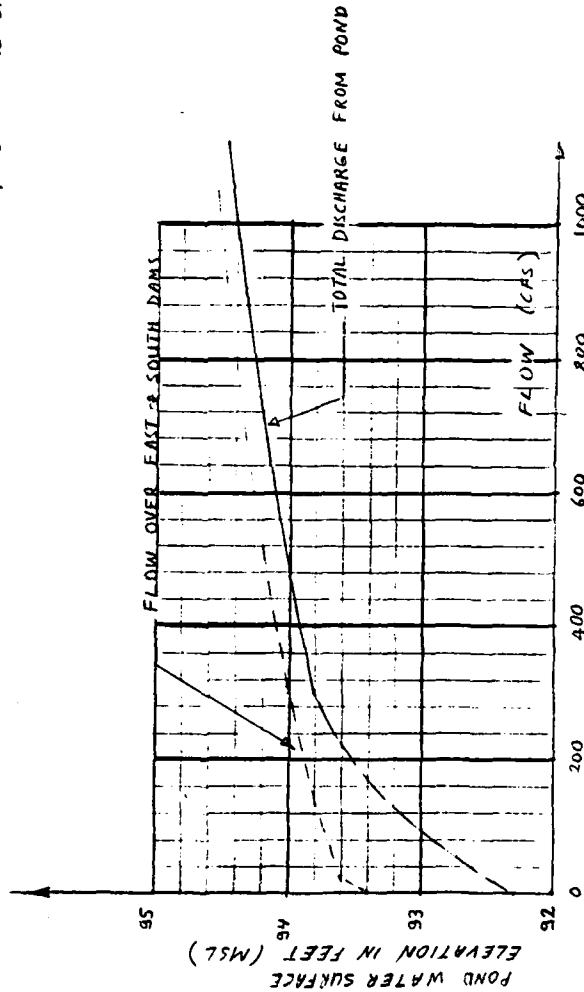
PAGE 4  
 DATE 2/12/79  
 COMPUTED BY AUG

ESTIMATED STAGE - DISCHARGE QUANTITIES

Flow (CFS)	WSE @ East of 41:54 Dam	Overflow East of Spillway @ Spillway	Δ h req'd	WSE in Pond
300	91.8	150	1.7	93.8
500	92.3	170	1.9	94.0
1,000	92.5	200	2.1	94.4

\* Effect of backflow from the downstream channel is included. Refer to tailwater studies.

DAM SITE	CREST	
	EL.	LENGTH (ft)
North Dam	95.5	470
" Spillway	92.3	19
East Dam	93.4	100
South Dyke	93.6	325
West Dam	95.4	400



STAGE - DISCHARGE  
 (THE SPILLWAY AT NORTH HAS 1.3-FT HIGH FLASHBOARDS)

CAMP DRESSER & MCKEE INC.

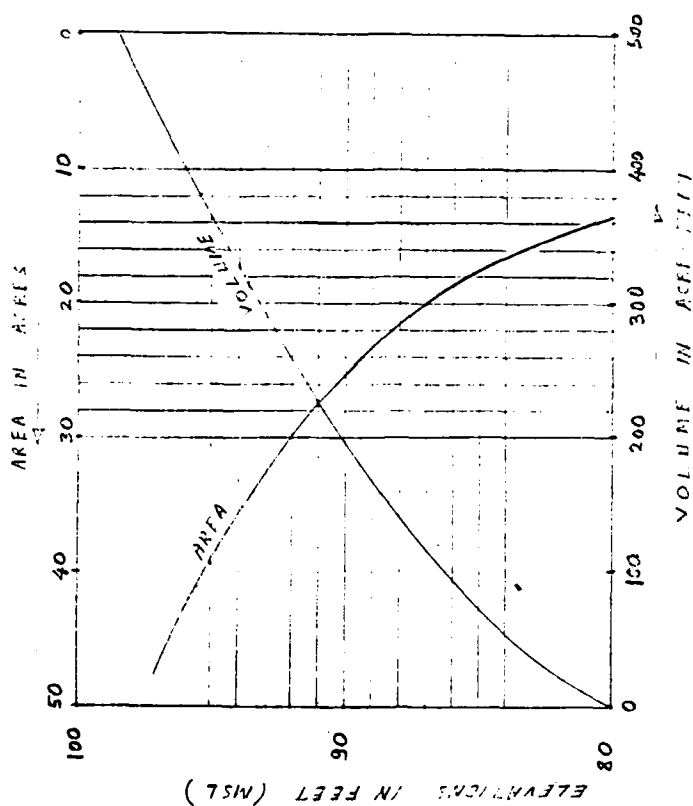
CLIENT HWA  
 PROJECT COE DAM INSPECTION  
 DETAIL PERFORMANCE TEST DAM

JOB NO 561-9-Pt-5  
 DATE CHECKED 3/20/79  
 CHECKED BY JED

PAGE 5  
 DATE 3/1/79  
 COMPUTED BY BLL

El.	Area (acres)	h (ft)	Volume (cu-ft) Partial	Σ
20	12.7	11	227	0
21	27.5	4	134	227
25	33.5	4	134	351

\* Areas estimated.



AREA - VOLUME CURVE

(Source: USGS Gloucester Quadrangle)

AD-A147 158

22  
NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS  
FERNWOOD LAKE DAM (MA...) (U) CORPS OF ENGINEERS WALTHAM  
MA NEW ENGLAND DIV APR 79

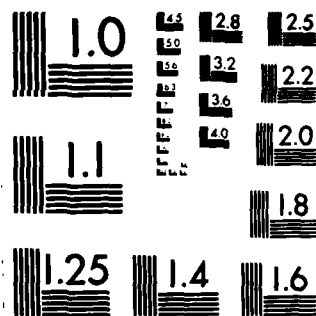
UNCLASSIFIED

F/G 13/2

NL



END  
DATE  
FILMED  
11-84  
DTIC



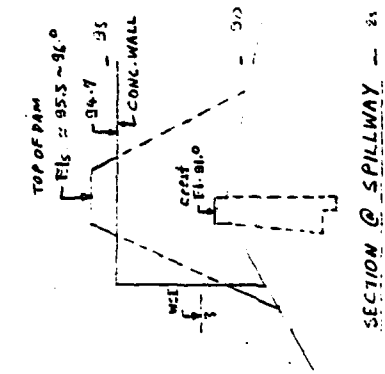
MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

CAMP DRESSER & MARSH INC.

CLIENT H&A  
 PROJECT CDE DAM INSPECTION  
 DETAIL FEHNEVED LAKE DAM

JOB NO 561-9-PI-5  
 DATE CHECKED 3/20/79  
 CHECKED BY ED

PAGE 6  
 DATE 3/2/79  
 COMPUTED BY AME

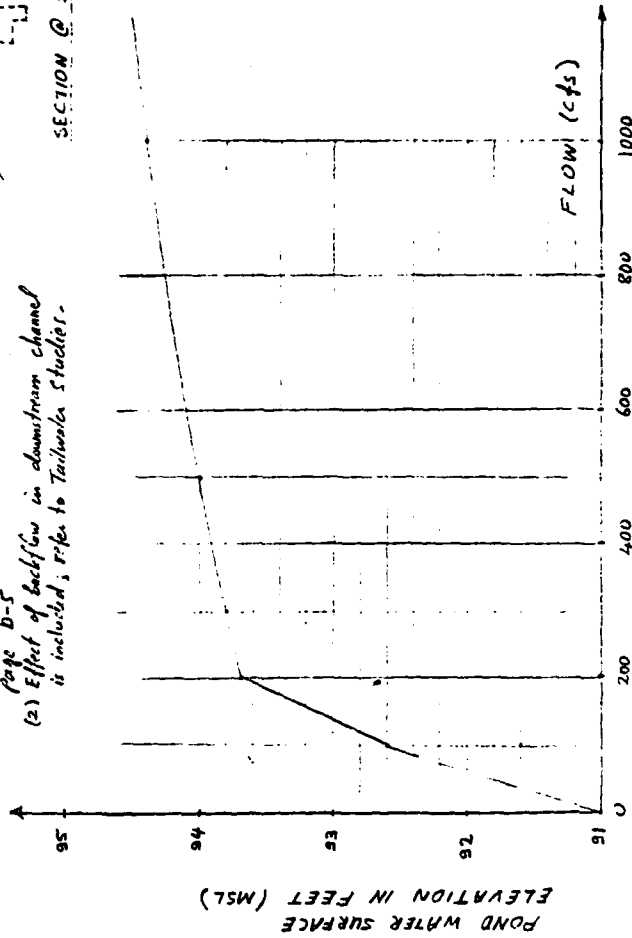


SECTION @ SPILLWAY

ESTIMATED STAGE-DISCHARGE QUANTITIES

Flow (cfs)	WSE @ start of damsite, Channel (ft.)	Overflow Exit South from 3	Overflow Spilling	Δh (ft) @ Spilling	WSE in Pond
100	91.3	-	100	1.3	92.6
200	91.8	70	130	1.8	93.7
300	92.0	140	160	2.0	93.8
500	92.0	335	165	2.0	94.0
1,000	92.1	830	170	2.0	94.4

Notes: (1) For length & elev. of the dam see Page D-5  
 (2) Effect of backflow in downstream channel is included; refer to Tailwater Studies.



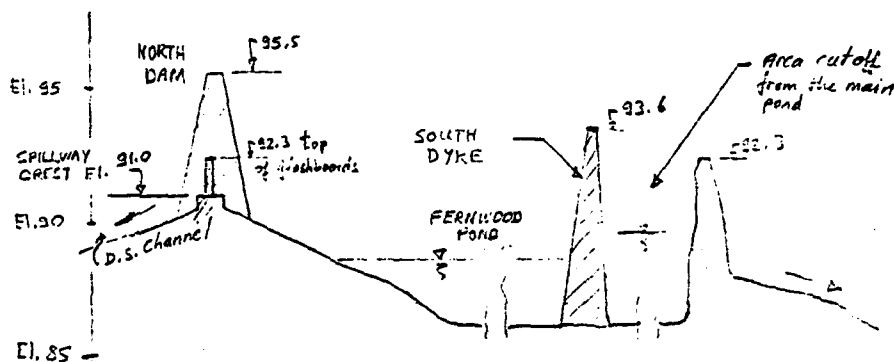
STAGE - DISCHARGE  
 (NO FLASHBOARDS @ SPILLWAY)  
 Crest El. 94.0

CLIENT H&A JOB NO. 561-9-Rt-5 PAGE 7  
 PROJECT CCE Dams Inspection DATE CHECKED 9/20/79 DATE 3/16/79  
 DETAIL Fernwood Lake Dams CHECKED BY JED COMPUTED BY MLM

Effects of backflow condition in the downstream channel was considered in the above studies (more on this under "Tailwater Studies").

Outflows for the two conditions were found to be the same because about half of the discharge from the pond is over the East and South dams (assuming that these embankments would remain intact). Overflows at the East dam would go into the Upper Bangs pond which has an outlet to the Lower Bangs pond which in turn discharges into the Ocean.

Any flow overtopping the South dyke ~~would~~ would fill the cutoff portion of the pond at the southern tip and then overflow into a swampy area which has a channel outlet to the Wallace pond. A schematic cross section of the pond is shown below:



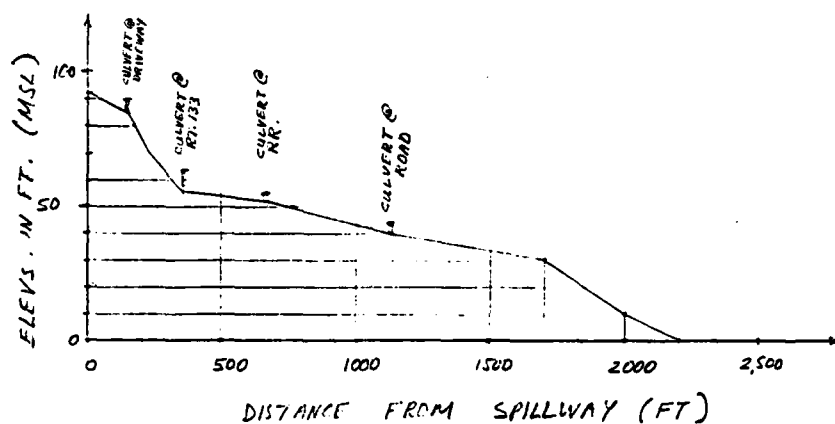
Conclusion: The spillway is adequate for the test flood whether the existing 1.3-foot high flashboards are left in place or not. However the South dyke and the East dam would be overtopped by about 0.2 and 0.4 feet, respectively.

CLIENT H & A  
 PROJECT CCE Dam Inspection  
 DETAIL Fernwood Lake Dam

JOB NO 561-9-PT-5PAGE 2DATE CHECKED 3/20/77DATE 3/17/77CHECKED BY JEDCOMPUTED BY RLG

### Downstream channel & Tailwater

An approximate profile of the downstream channel:



Culvert Underneath the Driveway:

Capacity:  $S \approx 0.04$   $\sqrt{S} = 0.2$   
 $D_1 = 12\text{-in}$   $A_1 = 0.78 \text{ ft}^2$   
 $D_2 = 18\text{-in}$   $A_2 = 1.76 \text{ ft}^2$   
 $R_{1,2} = 0.25$   $R_{1,2}^{1/2} = 0.4$   
 $R_2 = 0.38$   $R_2^{1/2} = 0.52$   
 $n = 0.015$

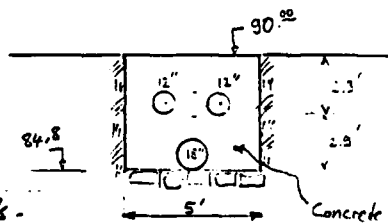
$$Q = \frac{1.49}{0.015} A R^{2/3} \cdot 0.2 \approx 20 A R^{2/3} \approx 35 \text{ cfs.}$$

If  $Q > 35 \text{ cfs}$  flow would overtop the road.

Stage - Discharge Curve:

culvert capacity:  $35 \sim 40 \text{ cfs.}$

Flow overtopping the road:  $Q = C L H^{3/2} = 2.5 \cdot 30 \cdot H^{3/2} = 75 H^{3/2}$

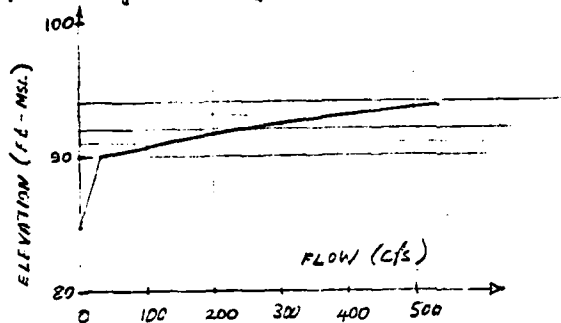


CLIENT HWA  
 PROJECT RAF Wain, Improvement  
 DETAIL Forwood Lane Drain

 JOB NO 561-9-R4-5  
 DATE CHECKED 9/27/77  
 CHECKED BY ED

 PAGE 2  
 DATE 2/17/77  
 COMPUTED BY AUG

		<u>E1.</u>
$Q_1 = 100 \text{ cfs} \rightarrow \Delta Q = 60 \text{ cfs} \rightarrow H_1 = 0.85 \text{ -ft}$		90.25
$Q_2 = 200 \text{ cfs} \rightarrow \Delta Q = 160 \text{ " } \rightarrow H_2 = 1.65 \text{ -ft}$		91.65
$Q_3 = 300 \text{ cfs} \rightarrow \Delta Q = 260 \text{ " } \rightarrow H_3 = 2.30 \text{ -ft}$		92.30
$Q_4 = 500 \text{ cfs} \rightarrow \Delta Q = 460 \text{ " } \rightarrow H_4 = 3.55$		93.55



STAGE - DISCHARGE CURVE @ DRIVEWAY CULVERT

Stage Capacity @ Earth Channel just below the Spillway

$$\text{Apron: } Q = \frac{1.49}{n} A R^{2/3} S^{1/2} \quad n = 0.025$$

$$Q_1 = 200 \text{ cfs} \rightarrow \text{WSE @ the culvert (driveway)} = 91.65 \approx 91.7$$

a) Downstream Section:

$$d_1 = 91.7 - 84.8 = 6.9 \text{ -ft} \quad A = 41.4 \text{ ft}^2 \quad R^{2/3} = 1.61 \quad \text{CHANNEL SECTION NEAR SPILLWAY APRON}$$

$$S_1 = 0.0025 \rightarrow \Delta h_1 = 154' \times S_1 \approx 0.4 \text{ -ft}$$

$$\text{MGL @ the apron: } 91.7 + 0.4 = 92.1$$

b) Upstream section:

$$d_2 = 92.1 - 89.4 = 2.7 \text{ ft} \quad A = 26.5 \text{ ft}^2 \quad R^{2/3} = 1.44$$

$$n = 0.025 \quad S_2 = 0.0076 \rightarrow S_{av} = 0.0050$$

$$\Delta h = 0.8 \quad \text{WSE at the apron: } 92.5$$

 c) Apron:  $W = 19'$  rectangular section,  $L = 17'$ 

$$\text{Elev. near Spillway: } 91 - 0.5 = 90.5$$

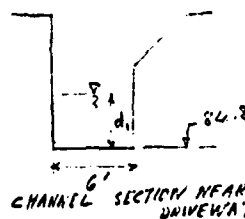
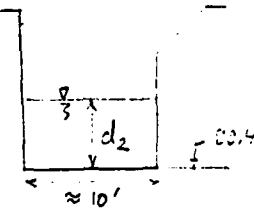
$$\text{WSE} = 92.5 + 17 \times 0.0076 = 92.63 \approx 92.6$$

$$d_3 = 92.6 - 90.5 = 2.1$$

$$Q = \frac{1.49}{0.025} A R^{2/3} S^{1/2} \quad A = 13 \times 19 = 247 \text{ ft}^2 \quad R^{2/3} = 1.45$$

$$S_3 = 0.0021 \quad S_{av} = 0.0048$$

$$\text{WSE @ Spillway: } 92.6$$



CLIENT H & A  
 PROJECT CCF Dam Inspection  
 DETAIL Fernwood Lake Dam

JOB NO 561-9-R1-5  
 DATE CHECKED 3/20/79  
 CHECKED BY IED

PAGE 10  
 DATE 3/17/79  
 COMPUTED BY AIG

$$Q_2 = 300 \text{ cfs} \rightarrow \text{WSE @ Culvert-Driveway} = 92.3$$

(a) Downstream section:  $300 \text{ cfs} = \frac{1.43}{0.075} A R^{2/3} S^{1/2}$   
 $d_1 = 92.3 - 84.8 = 7.5'$   $A = 45 \text{ ft}^2$   $R^{2/3} = 1.66 \rightarrow S_1 = 0.0048$   
 $\Delta h = 154 \times 0.0048 = 0.7 \text{ ft}$   $\text{WSE @ upstream} = 93.0$

(b) Upstream section:  $d_2 = 93.0 - 89.4 = 3.6' \rightarrow A = 36 \text{ ft}^2$   $R^{2/3} = 1.64$   
 $S_2 = 0.0072$   
 $S_{av} = 0.0055$   $\Delta H = 0.25 \approx 0.9$   $\text{HGL @ Apron} = 93.2$

(c) Apron:  $\text{WSE} = 93.2 + 17 \times 0.0072 = 93.3$   $d_3 = 2.8$   
 $A = 53.2$   $R^{2/3} = 1.67$   $S_3 = 0.0021$   $S_{av} = 0.0046$   
 $\Delta h_{\text{apron}} = 0.08 \approx 0.1$   $\text{HGL @ Spillway} = 93.3$

$$Q_3 = 500 \text{ cfs} \rightarrow \text{WSE @ Culvert-Driveway} = 93.6$$

(a) Downstream section:  $d_1 = 93.6 - 84.8 = 8.8 \text{ ft}$   $A = 53 \text{ ft}^2$   $R^{2/3} = 1.71$   
 $S_1 = 0.0084$   $\Delta h \approx 1.3$   $\text{WSE @ upstream} = 94.9$

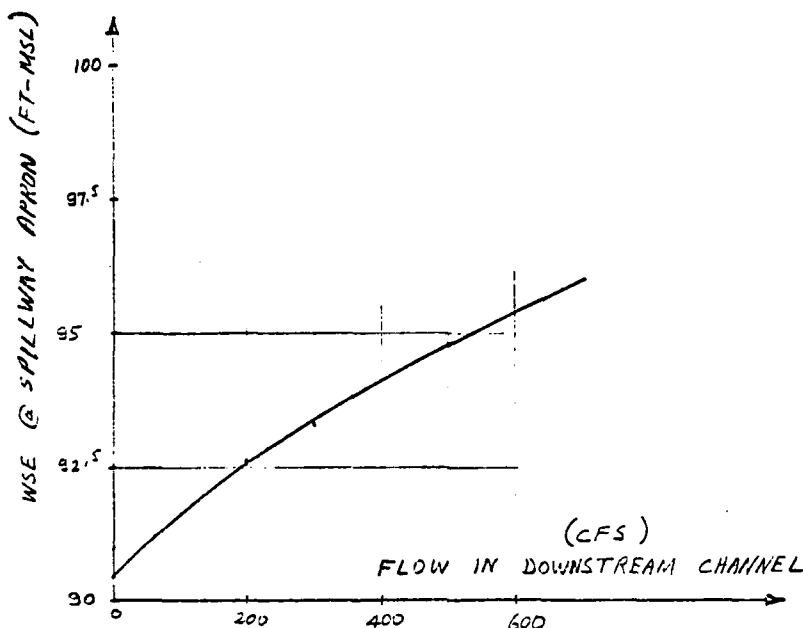
(b) Upstream section:  $d_2 = 94.9 - 89.4 = 5.5'$   $A = 55 \text{ ft}^2$   $R^{2/3} = 1.90$   
 $S_2 = 0.0064$   $S_{av} = 0.0074$   $\Delta h = 1.1$   
 $\text{HGL @ Apron} = 93.6 + 1.1 = 94.7$

(c) Apron:  $\text{WSE} = 94.7 + 17 \times 0.0064 = 94.8$   $d_3 = 4.3'$   
 $A = 81.7$   $R^{2/3} = 2.06$   $S_3 = 0.0016$   
 $S_{av} = 0.0040$   $\text{HGL @ Spillway} = 94.8$

The calculations above indicate that flow over the spillway crest would be affected by the backwater curve originating at the culvert under the driveway. This would be true for almost any significant flow when there is no flashboards; but it would happen for discharges greater than 180 cfs if the existing 1.3-ft flashboards are left in place. The backflow effect at the spillway (apron) is shown with the following curve:

CLIENT H&A  
 PROJECT COF Dam Inspection  
 DETAIL Forewood Lake Dam

 JOB NO 561-9-R1-5  
 DATE CHECKED 3/20/79  
 CHECKED BY ABD

 PAGE 11  
 DATE 3/17/79  
 COMPUTED BY AUG


After taking the backflow in the downstream channel and overtoppings at the South dike and at the East dam into consideration the estimated distribution of outflows from the pond was shown in pages D-5 and D-7.

The downstream channel beyond the driveway becomes steeper:

Check for  
 Test Flood:  $s = \frac{84.8 - 56.8}{210} = 0.13$   $fs = 0.36$   $q = 150 \text{ cfs}$

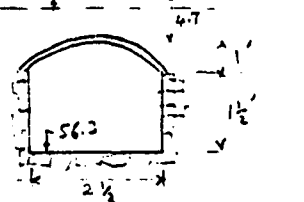
$n = 0.040$   $150 = \frac{1.49}{0.04} AR^{2/3} 0.36 = 13.4 AR^{2/3} \rightarrow d \approx 1.3 \text{ ft.}$

Capacity of the culvert at Rt. 132:

Assume  $s = 0.01$   $A = 2.5 \times 1.5 + 0.75 \times 1.5 = 5.6 \text{ ft}^2$   
 $R = 0.56$   $R^{1/4} = 0.62$   $n = 0.020$

$q_{max} \approx 30 \text{ cfs.}$

Excess flows would overflow the State Highway Route 132.



CLIENT H. A.  
 PROJECT CEE Dam Inspection  
 DETAIL Forward Lake Dam

 JOB NO 561-9-14-5  
 DATE CHECKED 3/20/79  
 CHECKED BY ED

 PAGE 12  
 DATE 3/17/79  
 COMPUTED BY RLG

### Dam Failure Analysis

$$\text{Failure Flood Flow: } Q_p = \frac{S}{27} W_b \sqrt{Y_0} Y_0^{3/2}$$

Assume  $L = 400$  - ft (crest-height of the dam (Total  $L = 470$  - ft).

$$W_b = 0.4 \times 400 = 160 \text{ - ft.}$$

$Y_0 = 19$  - ft at lowest point downstream of the dam.

$$Y_0^{3/2} = 22.5$$

$$Q_p \approx 22,000 \text{ cfs.}$$

There is no channel to carry this flow downstream of the dam. It will flow overland through a steep wooded area towards Route 133 and to the low lying areas along the channel.

#### Reach 1

Failure Outflow at Rt 133: Storage @ El. 95.5 = 320 ac-ft.

$$Q_{p2} = Q_p \left(1 - \frac{V_1}{S}\right) \quad Q_{p1} = 22,000 \text{ cfs.}$$

Flow depth: (a) at the beginning of the downstream sloping land:  
 $22,000 = \frac{4.49}{0.03} AR^{2/3} \sqrt{S} \quad S \approx 0.10 \quad \sqrt{S} = 0.32$   
 $AR^{2/3} = 1384 \quad d_1 = 2.1 \text{ - ft (by trial & error)}$

(b) at Route 133:

$$Q = 2.5 \times 400 \cdot d_2^{3/2} = 22,000 \quad d_2 \approx 8 \text{ - ft.}$$

$$V_1 \approx 12 \text{ ac-ft.} \quad \text{Ratio: } \frac{V_1}{S} = \frac{12}{380} = 0.03 \text{ negligible.}$$

The effect of the storage on the peak failure outflow in Reach 1 would be negligible. Thus, a flood wave of 8 - ft would reach to the area around Route 133.

Four single family homes and a garage-repair shop on the northern side of Route 133 (Essex Avenue), and possibly seven single family homes beyond the B&M railroad track, towards north, would be flooded. Depending on the location of the failure at the embankment one house 50 - ft west of the spillway, at the toe of the dam, and the driveway towards the spillway could be subject to flooding. Potential for loss of life and property damages exists.

**APPENDIX E - INFORMATION AS CONTAINED IN  
THE NATIONAL INVENTORY OF DAMS**

# INVENTORY OF DAMS IN THE UNITED STATES

DIS	OWN	FED	R	PRV	PED	SCS	A	VEN/DATE
NED	N	N	N	N		N		09APR79

~~44-SINCE 1952 47-FOR 1929 REPAIRS~~